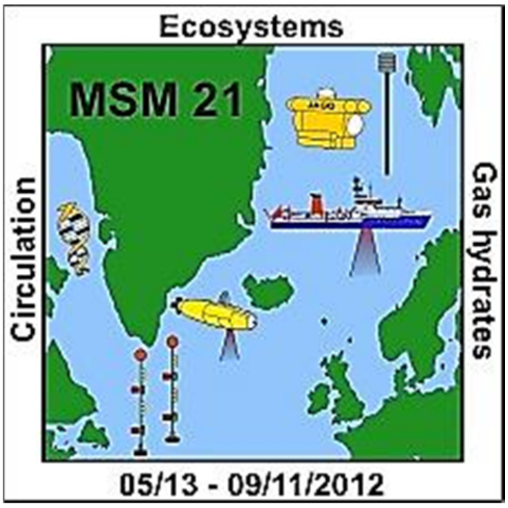
MARIA S. MERIAN-Berichte

North Atlantic Ventilation

Cruise No. MSM21/1b

June 9 – June 22, 2012,
Reykjavik (Iceland) – Reykjavik (Iceland)



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Content

1 Summary

The R/V MARIA S. MERIAN cruise MSM21/1b was carried out jointly by GEOMAR Kiel and the Institut für Meereskunde at the Centre for Marine and Atmospheric Sciences of Hamburg University. Scientists and technicians from the Atlantic Branch of the P.P. Shirshov Institute for Oceanology (Kaliningrad, Russia) and the Finnish Meteorological Institute (Helsinki; Finland) also participated in the cruise.

The measurements mainly contributed to three projects:

- “Nordatlantik”, funded by the German Ministry of Education and Research (BMBF)
- “THOR”, funded by the European Commission within the framework of FP7
- “Valley Mixing”, funded by the Deutsche Forschungsgemeinschaft (DFG)

The main objectives of the cruise were to characterize the spatio-temporal variability of the Denmark Strait overflow and to identify processes responsible for the exchange of the overflow plume with ambient water downstream of Denmark Strait. A multi-platform approach was taken to achieve the goals, based on moorings, an autonomous underwater vehicle (AUV), as well as lowered and vessel-mounted observations. From these platforms, measurements of temperature, salinity, dissolved oxygen, current velocity, dissipation of turbulent kinetic energy, and bottom pressure were obtained. Altogether, twelve moorings were deployed, one mooring was recovered, data from two PIES were uploaded via acoustic telemetry, turbulence measurements on six extended AUV dives were carried out, and 92 CTD / LADCP casts were taken, 25 of which had additionally been equipped with a profiling turbulence (MSS) probe. Along with this, underway data of surface hydrography and current velocity were collected throughout the cruise.

Our research was conducted in the spirit of both the "OSPAR Code of Conduct for Responsible Marine Research“ and the „Commitment of responsible marine research“ by the DFG Senatskommission.

Zusammenfassung

Die R/V MARIA S. MERIAN Fahrt MSM21/1b wurde unter Zusammenarbeit des GEOMAR Kiel und des Instituts für Meereskunde am Zentrum für Marine und Atmosphärische Wissenschaften (ZMAW) der Universität Hamburg ausgetragen. Des Weiteren nahmen Wissenschaftler und Techniker des P.P. Shirshov Instituts für Ozeanologie (Kaliningrad, Russland) und des finnischen meteorologischen Instituts (Helsinki, Finnland) an der Fahrt teil.

Die Messungen standen hauptsächlich mit den folgenden drei Projekten in Verbindung:

- „Nordatlantik“, finanziert durch das Bundesministerium für Bildung und Forschung (BMBF)
- „THOR“, finanziert durch die Europäische Kommission im Rahmen des FP7
- „Valley Mixing“, finanziert durch die Deutsche Forschungsgemeinschaft (DFG)

Das Hauptaugenmerk der Fahrt lag auf der Charakterisierung der raum-zeitlichen Variabilität des Ausstroms in der Dänemark Straße und der Identifizierung möglicher Prozesse, die für den Austausch des Ausstrom-Plumes mit den ihn umgebenen Wassermassen stromabwärts der Dänemark Straße verantwortlich sind. Die Untersuchungen wurden unter Verwendung von unterschiedlichen Plattformen - Verankerungen, einem autonomen Unterwasserfahrzeug (autonomous underwater vehicle, AUV) sowie schiffsgebundene Messungen - durchgeführt. Dabei wurden Temperatur, Salzgehalt, gelöster Sauerstoff, Strömungsgeschwindigkeiten, Dissipation der turbulenten Energie und Bodendruck gemessen. Insgesamt wurden zwölf Verankerungen ausgelegt. Eine Verankerung wurde wieder aufgenommen, die Daten von zwei Bodenecholoten (PIES) wurden via akustischer Telemetrie übertragen, sechs zusätzliche AUV-Tauchgänge führten Turbulenzmessungen durch und es wurden 92 CTD / LADCP Profile (25 inklusive Mikrostruktursonde (MSS)) aufgezeichnet. Außerdem wurden während der gesamten Fahrt Daten der Oberflächen-Hydrografie und Strömungsgeschwindigkeiten aufgenommen.

Die Fahrt ist unter dem Grundgedanken des „OSPAR Code of Conduct for Responsible Marine Research“ sowie des „Commitment of responsible marine research“ der DFG Senatskommission durchgeführt worden.

2 Participants

	Name	Operation	Institute
1	Torsten Kanzow, Prof. Dr.	Chief scientist	GEOMAR
2	Klas Lackschewitz, Dr.	AUV team leader	GEOMAR
3	Uwe Koy	Instrument technician	GEOMAR
4	Sandra Tippenhauer, Dipl. Phys.	AUV Microstructure; CTD watch	GEOMAR
5	Marcel Rothenbeck	AUV engineer	GEOMAR

	Name	Operation	Institute
6	Jan Sticklus	AUV engineer	GEOMAR
7	Momme Deutschmann	AUV engineer	GEOMAR
8	Nadine Mengis, B.Sc.	CTD watch; underway data; calibration	GEOMAR
9	Kerstin Jochumsen, Dr.	LADCP&hydrography analysis, CTD watch	IFM HH
10	Detlef Quadfasel, Prof. Dr.	Moorings; CTD watch; EM120 calibration	IFM HH
11	Ulrich Drübbisch	Mooring technician; CTD watch	IFM HH
12	Andreas Welsch	Mooring technician, CTD watch	IFM HH
13	Nuno Nunes	Oxygen titration; VMADCP; CTD watch	IFM HH
14	Bert Rudels, Dr.	CTD watch; hydrography analysis	FMI; HU
15	Tina Rabenseifner	CTD watch, salinometry	Leitstelle
16	Vadim Paka, Prof. Dr.	Microstructure	AB-SIO
17	Vladimir Baranov	Microstructure	AB-SIO
18	Kari Guddal	CTD watch; Arts	---

GEOMAR: Helmholtz Centre for Ocean Research Kiel, Germany

IFM HH: Institut für Meereskunde at the Centre for Marine and Atmospheric Sciences of Hamburg University

FMI; HU: Finnish Meteorological Institute; Helsinki University, Finland

AB-SIO: Atlantic Branch of Shirshov Institute of Oceanology, Kaliningrad, Russia

For list of crew member please see **Fehler! Verweisquelle konnte nicht gefunden werden.**.

3 Research Program

During the MSM21_1b cruise leg, we put a focus on the variations in time and space of the Denmark Strait overflow plume. Scientific objectives were:

- Variability of the strength of the export of dense water from the Nordic Seas to the North Atlantic.
- Dynamics of the overflow in the sill region and immediately downstream of it.
- Small scale horizontal distribution of turbulent mixing associated with entrainment ˜ into the overflow plume
- Changes of the water mass properties in the strait and downstream of it

Overflow in Denmark Strait (work area 1): Direct current measurements in the Denmark Strait Overflow have been carried out systematically since 1999. Macrander et al. (2005) calculated a mean transport of 3.3 Sv for the time period 1999-2003. The overflow exhibits strong interannual and intraseasonal fluctuations, with amplitudes of up to 0.5 Sv. These can be linked to variations in the upstream reservoir height of the dense water pool, confirming the hydraulic control of the exchange postulated earlier (Girton, 2001). Käse (2006) showed that the interannual variability of overflow transport and reservoir height can in turn be linked to the atmospheric buoyancy forcing in the Nordic Seas, leading to the winter production of the dense water.

Our main technical goals in work area 1 were to (i) service the ADCP / PIES mooring array in Denmark Strait in order to extend the DSOW transport time series, and (ii) carry out a high-resolution hydrographic section (T, S, P, O2) along with velocity measurements (LADCP / VMADCP) across Denmark Strait.

Entrainment into the Overflow-Plume (Work Area 2): Along its path from Denmark Strait to the southern tip of Greenland the water mass characteristics of the overflow change, due to entrainment of ambient waters (Smith, 1976). Temperatures in the plume increase by about 2 K while its salinity decreases slightly. Consequently also the plume density decreases, but the contrast to the ambient water is still large enough for the plume to sink to more than 2000 m depth. Using the time series of currents and temperature along three moored arrays downstream of the Denmark Strait sill and repeated hydrographic section data, Voet (2006) and Voet and Quadfasel (2010) showed the dominance of horizontal stirring by meso-scale eddies for the entrainment of ambient water into the overflow plume. Only within 100 km of the sill does vertical mixing through shear instabilities seem to dominate the entrainment process. This was recently studied during MSM12/1 when microstructure profiles were taken along with the classical CTD and lowered ADCP profiles by V. Paka (SIO). Indeed does the analysis of the turbulence profiles show enhanced mixing at the upper interface of the sinking plume.

Our aim was to carry out an experiment capable of resolving meso- and submesoscale flow and hydrography variations of the DSOW plume with the aim of documenting and quantifying the mixing and entrainment in the plume. Our tools included lowered, moored and autonomously navigating platforms:

- CTD- O2/lADCP profiling plus the use of a microstructure probe to quantify the level of turbulence at the plume interface.
- deployment of a small scale mooring array in the high energy region of the plume (which was successfully recovered in August 2012 aboard R/V POSDEIDON).
- GEOMAR's AUV Absyss equipped with a microstructure probe, and a CTD to resolve the horizontal scales associated with turbulent entrainment in the shear zone at the plume interface

4 Narrative of the Cruise

On Saturday, June 9, 2012, R/V MARIA S. MERIAN left Reykjavik at 8 am. After a successful one-hour test dive of the AUV Abyss in calm seas in the bay of Reykjavik, we steamed toward Denmark Strait – our first work area (see **Fig. 4.1**). Fortunately, the 38 KHz ADCP with the beamformer board from FS METEOR installed during the port stop in Reykjavik proved to work reliably. In Denmark Strait, we commenced our work in the early morning of June 10, by uploading data from a PIES via acoustic telemetry, which had been deployed approximately one year earlier. After that we carried out a CTD/LADCP section across Denmark Strait, starting from the southeast, measuring both the warm, saline Irminger current and the cold, dense Denmark Strait overflow. Ice coverage made it impossible to complete the three northern-most stations on the

Greenland side of the strait. On the way an ADCP mooring was recovered after one year of operation. We concluded our work in Denmark Strait after having uploaded one year's worth of data via acoustic telemetry from a second PIES. In calms seas, in the evening of June 11, we arrived in the second work area (see Fig. 4.2), located on the Greenland continental slope southwest of Denmark Strait. We stayed in this area with short interruptions until June 20. Here, the overflow plume exhibits an intense exchange with ambient Atlantic waters, accomplished by both lateral and vertical mixing. First CTD casts used for both mooring release tests and the calibration of instruments to be moored were carried out. In the central part of the planned mooring cluster 3 transponders to be used as AUV navigation aids were deployed. Subsequently, a topographic survey using R/V MERIAN's swath echo sounder was carried out to guide the planning of AUV missions in this area.

In the evening of June 12 we deployed 4 ADCP moorings. Later that evening the AUV Abyss – equipped with a microstructure (turbulence) probe and a conventional CTD – was launched for its first extended mission in the overflow. After completion, the AUV was recovered approximately twelve hours later in the morning of June 13. To determine the stratification, parallel to the AUV mission local CTD / LADCP casts were carried out. The special aspect about our CTD casts is, that on some of them a profiling microstructure turbulence sensor (MSS) was used (similar to that attached to the AUV) whose release from the CTD frame at a desired depth was triggered via the CTD deck unit. In the following days we completed the mooring cluster, which consisted of a total of twelve moorings in our approximately 20 nm by 12 nm wide work area. The moorings were to be recovered approximately two months later by R/V POSDEIDON. We carried out repeated CTD / LADCP / MSS measurements at two sites, with one located near the center of the mooring cluster, and the other south of this location, near the offshore limit of the overflow plume. In parallel, AUV missions with different configurations were carried out in the overflow plume, of which in total 5 missions were successful.

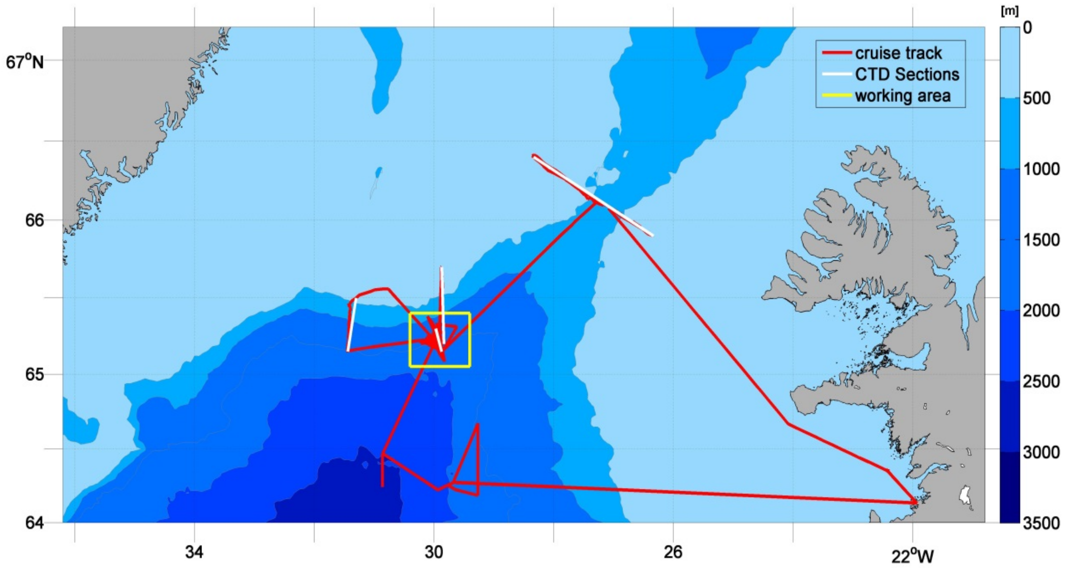


Fig. 4.1 MSM21/1b cruise track, hydrographic section and main work area (yellow box).

In addition, near the work area, we carried out measurements along two sections from the Greenland shelf down the continental slope. Surprisingly, in the western (downstream) one, completed on June 15, water with densities in excess of 27.9 kg m^{-3} were found in a bottom layer extending all the way from the shelf down into the overflow plume. To establish the origin of the dense water, on June 18 we carried out CTD /LADCP measurements along a second section down the Greenland continental slope, located 35 nm east of the first one. In between the two sections there was a pronounced topographic depression in the Greenland shelf. The data from the second section did not show water with densities in excess of 27.8 kg m^{-3} and 27.9 kg m^{-3} at water depths shallower than 800 m and 1400 m, respectively. After having recovered the AUV navigation transponders, we left the main work area in the evening of June 20, to carry out a calibration of the EM120 swath echo sounder. After the completion of this task, we steamed back to Reykjavik where we arrived in the morning of June 22.

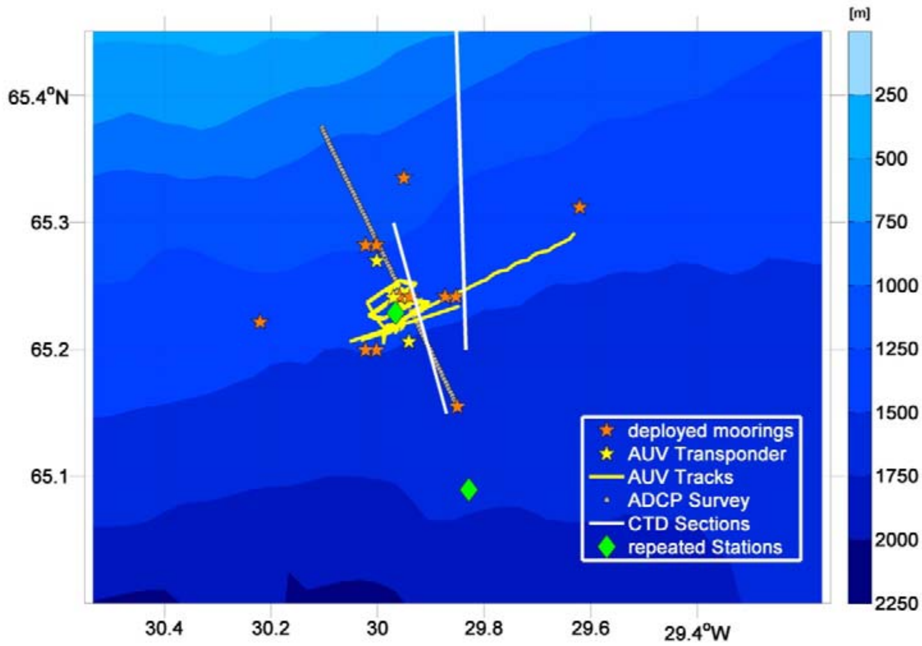


Fig. 4.2 MSM21/1b stations covered in the main work area.

5 Preliminary Results

5.1 Lowered CTD

5.1.1 System and operations

(Nadine Mengis)

During the cruise from 09 June to 22 June 2012 a total of 92 CTD profiles of were carried out. The purpose of these were to (i) sample different sections of the DSOW plume (white lines in Fig. 4.1 and Fig. 4.2), (ii) characterize the temporal variability of the DSOW plume at fixed locations (green points in Fig. 4.2), and (iii) to calibrate MicroCats attached to the frame of the CTD. During 25 of the profiles the frame had additionally been equipped with a profiling microstructure (MSS) probe (see section 5.4). We used a standard CTD SBE 911+ System (GEOMAR System No. 4) equipped with a pressure sensor, two pairs of Seabird temperature / conductivity sensors, two oxygen sensors, and combined fluorescence / turbidity CDOM sensor (see *Table 5.1*). The CTD was mounted on the GO4 rosette frame with a 24 bottle rosette sampling system with 10 l bottles. In varying configurations a maximum of 8 bottles were used to take water samples. A downward looking altimeter, with a range of ~100m was installed, so that the distance to the bottom could be determined with a high accuracy. The CTD profiles usually ended 10m above the sea floor. In addition, ocean current measurements were carried out during the casts using two ADCPs attached to the CTD frame, with one looking up and the other looking down (see section 5.2).

The CTD deck unit, a computer system used for data logging and triggering the water samplers, and a GPS receiver were jointly installed in the rack CTD-DU 03. Data was recorded using the SeasaveV7 software, which takes time and position information from the GPS clock correction and timeserver software. For easier processing (application of calibrations, etc.) the numbers of the CTD casts were continued from the previous cruise (MSM21_1a; chief scientist Johannes Karstensen). The first CTD profile of our cruise (MSM_21_1b) therefore had the profile number #94.

Device	Model number	Serial number
CTD deck unit	SBE 11 plus	SN 11P22348-0530
CTD underwater unit	SBE 9 plus	SN 00P34783-0752
Pressure Sensor	Paroscientific Digiquartz	SN 89964
Temperature, primary	SBE 3	SN 4956 (profiles 1 - 6); SN 1294 (profiles > 6)
Temperature, second	SBE 3	SN 2814
Conductivity, primary	SBE 4	SN 3425
Conductivity, second	SBE 4	SN 3981
Oxygen, primary	SBE 43	SN 0145
Oxygen, second	SBE 43	SN 0985
Fluorescence and Turbidity	Wetlabs, FLNTU	SN 2294
Altimeter	Teledyne	SN 42106

Table 5.1: Setup of the CTD system during MSM21/1b

Some problems regarding the CTD data quality had been reported from the previous leg (MSM21_1a) and further investigations regarding these were made during MSM21_1 (see Table 5.2). It was found, that the times when the two temperature sensors were divergent, coincided with divergent conductivities between the two sensors. Changing the pump system before CTD profile 113 solved the problem. Only on one occasion later in the cruise significant differences between the two CTD pairs were observed. This occurred during profile 133, when the second pump did not work for several minutes. For safety reasons the ship was moved sideways during all CTD stations with the MSS attached (section 5.4) and additionally during profiles 99, 100, 107, 108 and 142. Specific information on the CTD profiles (repeated mode, yoyo, use of MSS, etc.) can be obtained from Table 5.2.

5.1.2 CTD calibration

During the two legs of MSM 21 a total of 189 CTD-profiles were collected. The final calibration was carried out using the joint data set collected during both legs. A GEOMAR Guildline Autosal salinometer was used for CTD conductivity cell calibration (operated by Florian Schütte during leg A and by Tina Rabenseifner during leg B). Calibration during operation was done in two ways: IAPSO Standard Seawater was measured at the beginning of the salinometer use. In addition, a so called “substandard” (essentially a large volume of water with constant but unknown salinity), obtained from deep bottles from the CTD casts was used to track the stability of the system.

The conductivity calibration of the downcast data was performed using a linear fit with respect to conductivity, temperature, and pressure (for all profiles secondary set of sensors was used and calibrated with C_corrected = C_observed 0.0082172 + 4.357e-08 * P + 0.00022652 * T -0.0025601 * C). Using 67% of the 402 samples for calibration a r.m.s. Of 0.00012 S/m corresponding to a salinity of 0.0014 PSU was found for the downcast. We chose the downcast as final dataset as: 1) Sensor hysteresis starts from a well defined point, and 2) the incoming flow is not perturbed by turbulence generated by the CTD-rosette.

Table 5.2: Specific comments to CTD profiles.

Profile	Comment	Position
94	test ctd	64° 21.05 N 22° 24.73 W
101	MSS; aborted due to problems with MSS	66° 2.99 N 26° 57.04 W
106	MSS; MSS was only released at the surface	66° 8.96 N 27° 23.04 W
128	Reference for AUV with MSS	65° 12.80 N 29° 57.92 W
167	MSS	65° 24.00 N 29° 50.96 W
117-121	Repeated CTD with MSS; #118 MSS only released at the surface	65° 14.10 N 29° 57.51 W
122-127, 151-153	Repeated CTD mit MSS	65° 5.36 N 29° 49.70 W
154	Yoyo CTD , between 1600m and bottom	65° 5.36 N 29° 49.68 W
129-133	Repeated CTD with MSS	65° 12.80 N 29° 57.99 W
144-150, 156 160, 171, 174, 178-180	Repeated CTD with MSS	65° 13.74 N 29° 57.99 W

Profile	Comment	Position
172-173, 177	Yoyo CTD , between 1000m and bottom	65° 13.74 N 29° 57.99 W
175-176, 181-185	Repeated CTD without MSS	65° 13.74 N 29° 57.99 W

5.1.3 Preliminary analysis of lowered CTD measurements

(Bert Rudels)

5.1.3.1 Introduction

The CTD measurements made on the MSM 21-1b cruise can best be separated into two categories, sections and time series. Three sections were occupied; the first along the sill in Denmark Strait, the second running north-south across the continental slope at 29°58'W and the third from south to north across the slope near 31° 20' W. The last two sections were separated by a fairly deep (~500m) depression or canyon at the shelf and slope that would allow for intensified shelf-slope-basin interactions. The time series were mostly carried out at the centre of the working area and the mooring array at about 1430 m depth. Four time series between 6 and 10 hours were obtained here and one time series of about 6 hours was taken in the southern, deepest part of the working area at a depth of 1760 m. The time series were mainly carried out in combination with the microstructure measurements conducted with the free-falling Baklan microstructure probe (section 0). In instances, when the microstructure observations were not taken, yo-yo CTDs were made through the deepest 300 m to 500 m of the water column observing the changing characteristics of the overflow plume.

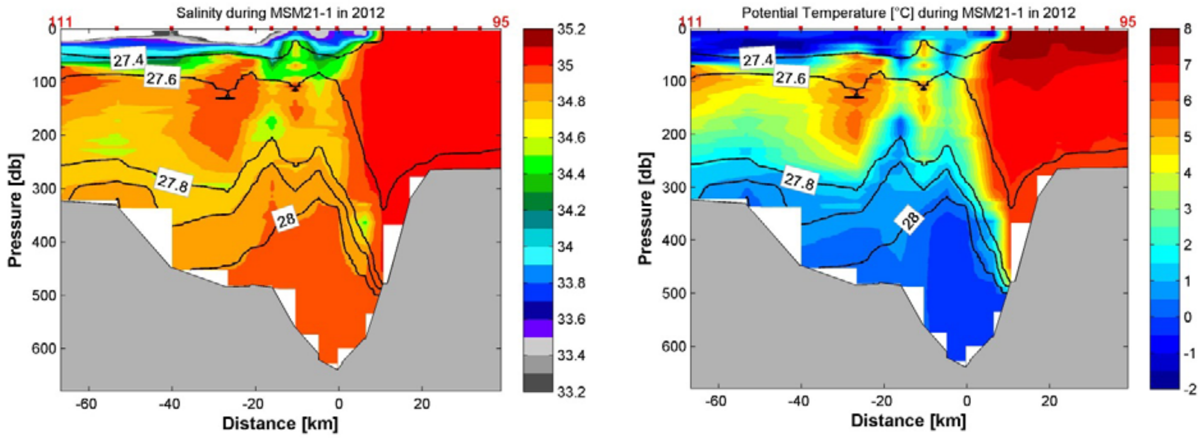


Fig. 5.1 Section of salinity (left) and potential temperature (right) across Denmark Strait. Red dots indicate positions of profiles.

5.1.3.2 The Sections

The first section was taken along the sill in Denmark Strait from Iceland towards Greenland (**Fig. 5.1**). The eastern part of the section over the Iceland continental shelf was occupied by warm northward flowing water from the Icelandic branch of the Irminger Current. As the sill deepened towards the west a sharp front was encountered, separating the northward flow from the southward moving waters from the Nordic Seas. In the deep (640 m) channel the deepest 200 m were occupied by cold (–0.4°C), fairly saline (34.905) and dense water, forming the densest water mass on the section. Earlier investigations (e.g. Jónsson and Valdimarsson, 2004) have shown that this dense water derives from a barotropic jet located above the 600 m isobath on the northern Icelandic shelf.

Farther to the west waters from the East Greenland Current were encountered. Close to the bottom the water had a temperature between 0°C and 1°C with salinity just below 34.9. These characteristics suggest either much diluted Recirculating Atlantic Water (RAW) from Fram Strait or the colder, less saline Arctic Atlantic Water (AAW) deriving from Atlantic water that has entered and is returning from the Arctic Ocean. Above this layer the salinity decreased and the temperature increased and the 27.8 isopycnal, traditionally defining the overflow water (Dickson and Brown, 1994), was located about 100 m above the bottom of the 350 m deep shelf. At 200 m warmer, more saline water was present, indicating either a recirculation or a detached eddy of the Irminger Current that had entered the East Greenland Current (the corresponding velocity distribution is shown in Fig. 5.7). In the western part a low salinity cold surface layer was present, showing the outflow of low density Polar water. Because of ice and fog the section could not be extended as far west as planned and most of the low salinity Polar water in the upper part of the water column was probably not observed.

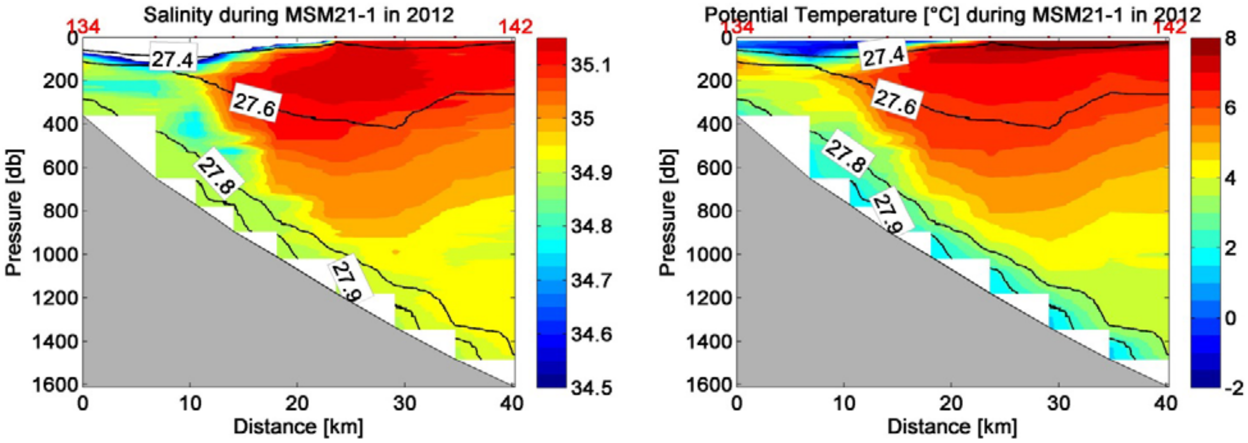


Fig. 5.2 Sections of salinity (left) and temperature (right) down the Greenland continental slope near 31° 20' W. Waters denser than 27.8 kg m-3 were present in all profiles.

The second section was taken south of the sill from the shelf down the continental slope into the deep Irminger Basin near 31° 20'W (see **Fig. 5.2**). The section was located west a 500 m deep depression that could act as a channel, allowing dense water from the north, which had passed south on the shelf west of the deep part in Denmark Strait, to sink from the shelf into the deep Irminger Basin. The observation showed that the 27.8 isopycnal was present from the shelf and the 27.9 isopycnal from 600 m continuously down to deeper than 1500 m. The temperature was between 1°C and 2°C and the salinity slightly below 34.9. The section lies east, or upstream, of the "spilljet" section discussed by Pickart et al. (2005). However, in comparison with their section the 27.8 and the 27.9 isopycnals extended much higher up on the slope, and no separation in density and in properties between the dense water on the shelf and the overflow plume found at 1500-1600 m could be seen. The dense water at the upper part of the slope was connected with the main overflow. This could be due to the presence of the depression, which channels dense shelf water deep down the slope, allowing it to join the initial overflow plume.

This assumption is somewhat vindicated by the observations made on the third section taken east of the depression. Here the upper part of the slope was occupied by warm Irminger Current water and only below 800 m was water with density above 27.8 kg m^{-3} present. Water with density above 27.9 kg m^{-3} was only seen on the deepest station at 1400 m. The temperature of this water was also fairly high, around 2°C. This suggests that, at least on this occasion, the depression could be a second, more southerly, source of overflow water, initially separated from the sill contribution but dense enough to join the main overflow farther south. This is in contrast to the "spilljet", which commonly has been observed to be less dense than 27.8 kg m^{-3} (Brearley et al., 2012). A second possibility is that a time variability of the overflow was observed and that pulses of dense water from the sill move along the slope. One of these was then seen on second section while no pulse was present when the third section was taken.

5.1.3.3 Time Series

Our time series were taken at the centre of the observational area and the mooring array close to 65° 13’ N/29° 58’ W and one time series at the southern deepest part of the research area. At the southern station the overflow plume was very thin, ~30 m, indicating that most of the overflow was located higher up on the slope. The water denser than 27.8 kg m^{-3} was also fairly warm and saline, implying mixing and entrainment with ambient water, probably caused by bottom generated turbulence that could extend across the entire depth of the thin plume.

On the time series taken at the central position of the study area the overflow plume was much thicker, often showing a 50-100 m thick, well mixed layer at the bottom (see **Fig. 5.3**). The temperature, salinity and density of the bottom layer varied considerably; ranging from about of 28.03 kg m^{-3} with salinity of 34.905 and temperature between 0.1°C and 0.5°C for the densest bottom layer to densities of 27.9 kg m^{-3} to 27.95 kg m^{-3} with temperatures from slightly below 1°C to 1.6°C and salinities between 34.8 and 34.9 for the less dense bottom layers.

Essentially three different contributions to the overflow plume can be identified. The densest water derives from the densest water passing through the deepest part of the sill and most likely comes from jet from the northern Iceland shelf. The less dense, warmer and less saline water would be supplied by the East Greenland Current found farther to the west. The more saline fraction would be drawn from the warm Atlantic layer, while the less saline water would come from the less dense thermocline but, because of the fairly high temperature, it could also contain some fraction of water from southern sources, perhaps some Irminger Current water being mixed into the overflow over the shelf at the sill. On several of the profiles the low salinity water mass was located above the more saline water, suggesting that these two water masses occasionally move on top of each other, perhaps all the way from the sill.

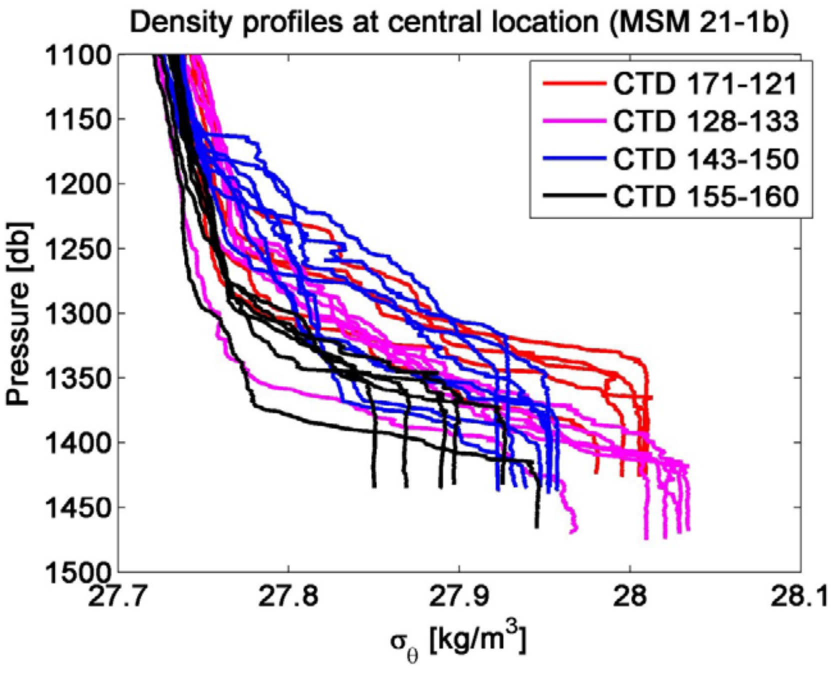


Fig. 5.3 Repeated density profiles near the central location (close to 65° 13’ N / 29° 58’ W). The different colours represent profiles that have been obtained within a period of less than 12 hours.

Regardless of which northern water mass that provides the deepest overflow layer, the layer between the plume and the ambient water usually exhibits two sharp gradients and a well-mixed layer in between. This could indicate that an initial single, sharp interface has become unstable, perhaps by Kelvin-Helmholtz instabilities and created an intermediate layer. This intermediate layer could, as the plume descends into denser surrounding waters, become detached from the plume and become mixed into the surrounding water column, making it colder and less saline.

The direct entrainment into the deep, homogenous part of the plume appears small regardless if the plume is comprised by the densest, cold component or by the less dense, less saline contributions. Some observed changes of the plume characteristics could actually be caused by a mixing between the initial components of the plume. The observed changes indicate an entrainment of 5-10 % of ambient water into the deep part. Only when the plume is thin as at the outer part of a meander or an eddy formed by the plume, does the bottom-generated turbulence create large enough entrainment to cause substantial changes in the properties of the overflow plume. This is in contrast to the instabilities generated at the interface, which rather would make the upper part of the plume merge with the ambient water.

5.1.4 CTD oxygen calibration

(Nuno Nunes)

5.1.4.1 Sampling

For the calibration of the CTD oxygen sensors, we followed the procedure established during the previous leg of the cruise, MSM 21/1a, and used the instrument setup for oxygen titration prepared by colleagues from GEOMAR, Kiel. Samples were taken for most CTD casts, usually three or four per station, depending on station depth. For each profile at the end of the downcast, the depths at which the Niskin bottles were closed during the upcast were chosen in order to sample minimum and maximum oxygen values. To help reduce any eventual sensor drift, the CTD was stopped at each chosen depth for about 10 seconds before closing the Niskin bottle.

With the CTD back on deck, samples for oxygen calibration were always collected from the Niskin bottles before salinity samples, to minimise contamination from atmospheric oxygen. Care was taken to keep the samples free from air bubbles. The sample collection and titration were done following the Winkler titration method, according to the indications of the GEOMAR colleagues. Each CTD watch had a person responsible for collecting the oxygen samples. In order to estimate the errors introduced by the sample procedure, duplicate samples were taken at most stations, usually from the bottle closed at the depth of minimum vertical gradient of oxygen concentration. This was normally the oxygen minimum.

5.1.4.2 Titration of bottle samples

After collection, the samples were stored in darkness for between 2 and 24 hours (minimum and maximum, respectively). At the start of each titration session, the concentration of the titration reagent (sodium thiosulfate) was precisely determined by titrating 10 ml of iodate standard solution. The value obtained was used to calibrate the dissolved oxygen concentration, measured by titration of the samples using the Winkler method. In total, 281 oxygen samples were measured at 84 stations during MSM 21/1b; for six samples, the values obtained were suspicious and they were therefore not used for the CTD calibration. Roughly half of the titrations were done by Nuno Nunes, the other half by Nadine Mengis.

5.1.4.3 Oxygen sensor calibration and preliminary results

The preliminary calibration of the CTD oxygen sensor was done on board by Nadine Mengis, and the final calibration for both cruise legs by Gerd Krahman, from GEOMAR, Kiel. **Fig. 5.4** shows the difference between bottle (titration) and sensor oxygen concentrations, before and after correction of the sensor measurements. Before the sensor correction, the bottle concentrations are typically 6 to 18 µg kg^{-1} higher than the sensor-inferred concentrations. After correction, the difference between the two is within ±2 µg kg^{-1}. A slight drift of the sensor towards smaller differences during the cruise is apparent before the calibration is applied. The calibration removes linear dependence on pressure, temperature and oxygen concentration of the difference between bottle and sensor measurements. The oxygen calibration of the downcast data was again performed using a linear fit with respect to oxygen concentration, temperature, and pressure. For all profiles except profile 86 the primary set of sensors was used and calibrated according to O_corrected = O_observed -6.4326 + 0.0021506 * P -0.074269 * T + 0.050136 * O). Using 67% of the 513 samples an r.m.s uncertainty of 1.13 µmol/kg was determined. Overall, the calibrated oxygen profiles appear to be a good quality, as is exemplarily shown using our data from Denmark Strait.

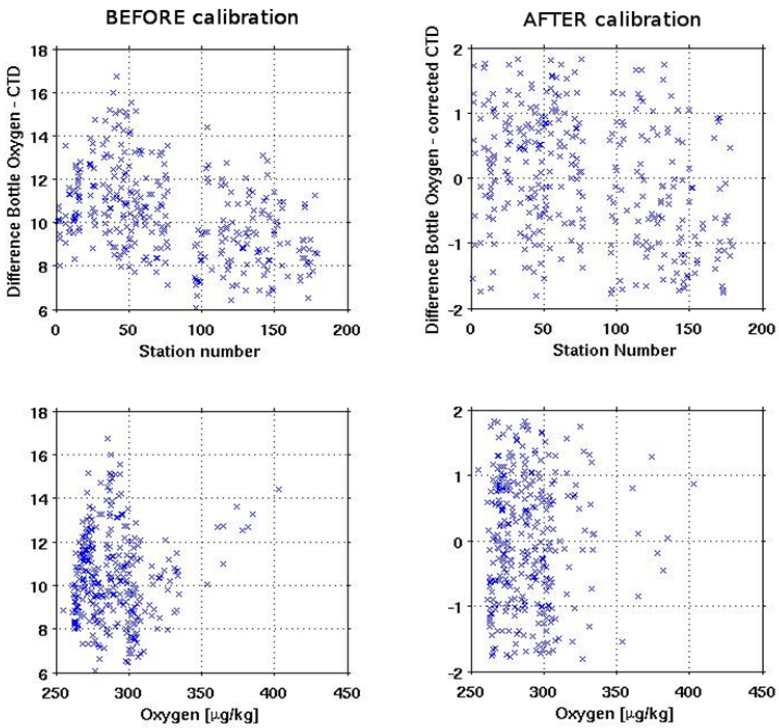


Fig. 5.4 Difference between bottle and CTD sensor oxygen concentrations, before and after applying the sensor calibration. The top row shows the difference as a function of station number, the bottom row as a function of bottle concentration. Data for the preceding leg of the cruise (MSM 21/1a, stations 1 – 77) is also shown.

Fig. 5.5 shows the distribution of dissolved oxygen along the Denmark Strait section. The waters in the overflow (DSOW, σ_θ>27.8) are more recently ventilated than the overlying layer. The somewhat patchy oxygen pattern along the 27.8 kg/m^3 isopycnal is mirrored by the distribution of salinity (Fig. 5.1) with higher oxygen concentrations being associated with negative salinity anomalies. The increasing solubility of oxygen with decreasing water temperature may explain the high oxygen concentrations near the surface in the northern part of the section (East Greenland Current). As expected, a sharp drop in oxygen is seen across the front toward the south, where the warm Atlantic inflow can be found. The data can be compared with the hydrographic sections (Fig. 5.1) and the velocity distribution (Fig. 5.7).

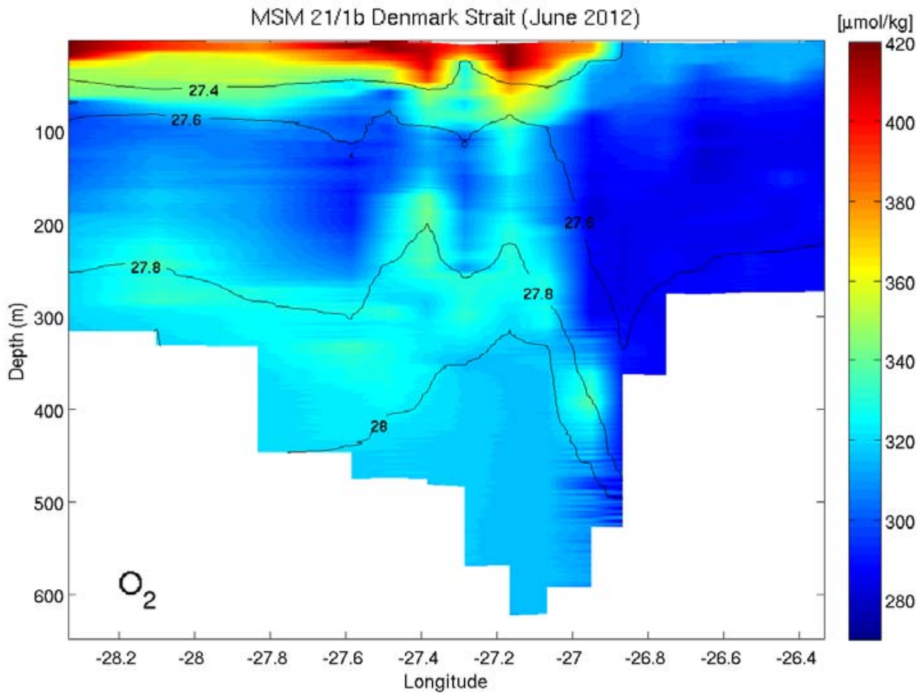


Fig. 5.5 Dissolved oxygen concentration on a section across the Denmark Strait. The black lines are contours of the density anomaly (σ_θ).

5.2 Velocity measurements using Lowered Acoustic Doppler Profilers (LADCP)

(Kerstin Jochumsen)

5.2.1 System and operation

On the CTD rosette system two Acoustic Doppler Current Profilers (150 kHz) were mounted, which were lowered with the rosette during a CTD station (therefore called LADCP). The upward looking instrument (SN 680) was run in the slave mode, while the downward looking instrument acted as master (SN 6468). Power supply was obtained through a battery housing (SN 003), connected to both instruments. All devices were the property of GEOMAR.

The upward looking ADCP showed weak beams 3 and 4 from the beginning. As the performance of beam 3 decreased even further, the instrument was removed after station 121. The backup

LADCP (SN 14411) from the University of Hamburg was installed, and the resulting current profiles were of good quality from now on.

At station 141 the connection between the lab computer and the LADCPs failed and could not be restored. Data exchange and programming of the instruments was then installed at the open hangar of MS MERIAN, using a toughbook laptop. Several communication errors occurred between stations 141 and 154, resulting in some stations with no data (141, 142, 148, 153) and some with data from only the down looking instrument (143, 144, 146, 147). The processing of station 152 failed, although there was reasonable raw data. This problem will likely be solved in the post processing procedure after the cruise.

Batteries were changed twice, after station 128 and after station 171. At station 171 the power supply broke and the measurements stopped shortly after the beginning of the station. There are no useful data for station 171.

5.2.2 Preliminary Results

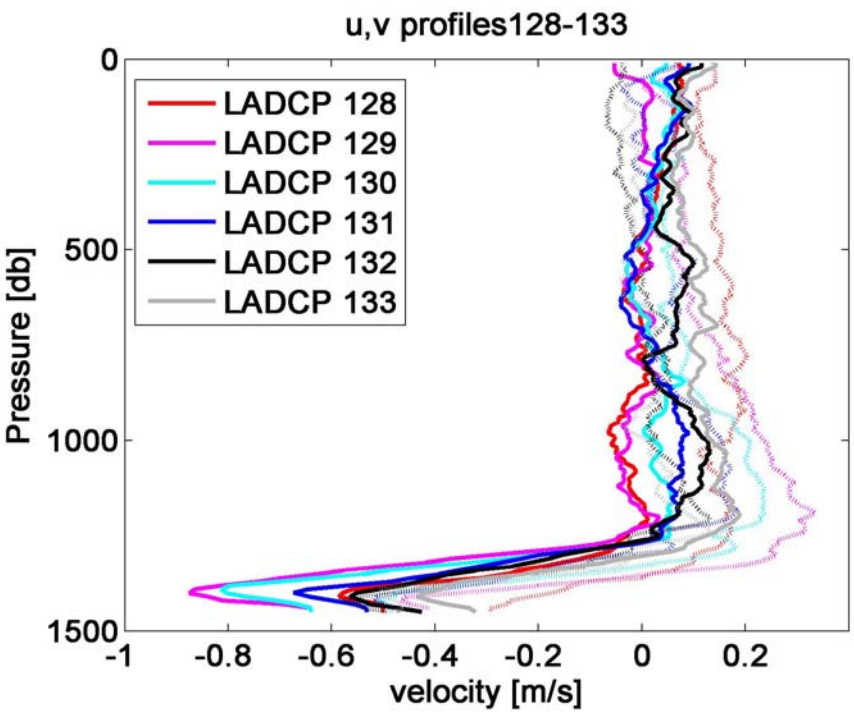


Fig. 5.6: u (solid lines) and v (dashed lines) velocity profiles 128-133 measured by the LADCP.

Generally, the velocity profiles appear to be of very good quality. Fig. 5.6 showed the eastward (u) and northward (v) velocities from 6 successive LADCP profiles which were acquired within 12 hours at the northern repeat station in the main working area (for orientation see Fig. 4.2). All of these profiles share typical characteristics which we repeatedly found in this area:

- comparingly weak flows in the upper ocean
- a sharp and well-defined shear zone above the DSOW overflow plume
- peak velocities of up to 1 m/s within the plume
- decreasing velocities toward the sea floor within the bottom boundary layer

In addition, this sequence of six profiles reveals changes in velocity of O(50 cm/s) within half a day. These changes are typical, and appear to be related to the passage of mesoscale eddies generated upstream by vortex stretching. We found the eddy-induced changes in the flow field in Fig. 5.6 to be clearly related to the properties of the DSOW plume, with the highest flow speed coinciding with the largest plume thickness and the lowest plume temperature (see also section Fig 5.1.2.3 and Fig. 5.3).

5.3 Vessel-mounted ADCP measurements

(Nuno Nunes)

5.3.1 Instrument setup and configuration

The RV MARIA S. MERIAN has two vessel mounted ADCPs, both RDI Ocean Surveyors, operating at frequencies of 38 kHz and 75 kHz. The 38 kHz instrument is installed in the midships shaft and usually provides good quality velocity measurements within a depth range of about 40 to 1400 m. A faulty transducer unit was repaired at the start of the cruise in Reykjavik, using a motherboard borrowed from a similar instrument on the RV Meteor. Following the repair, the instrument delivered good measurements throughout the cruise. At the end of the cruise, a new motherboard sent from RDI was due to be installed, and the one from RV Meteor returned. The 75 kHz instrument is installed in a hull mount towards the bow of the ship, 6 m below water level, and usually provides a useful depth range of about 10 to 700 m.

As noticed in previous cruises, simultaneous use of both ADCPs causes interference on the 75 kHz measurements, but the 38 kHz data remains clean, probably due to the stronger back scatter of the later signal. Since the focus of this cruise was on velocities below 1000 m depth, the longer range of the 38 kHz ADCP was considered more important than the higher resolution of the 75 kHz instrument. In practical terms, this means that both instruments were used, and interference on the 75 kHz data from the 38 kHz unit was overlooked.

Due to the strong mooring component of the cruise and the AUV operation, both ADCPs were frequently switched off for relatively short periods (a few hours) to avoid interfering with acoustic releasers and transponders. For a better characterization of the currents encountered in the work region, a few dedicated VMADCP sections were done.

Both instruments were controlled from dedicated PCs using the software VmDas, version 1.46, to send the startup commands to the respective deck units and save the data received from them. The setup used for the cruise was as follows: for the 38 kHz instrument, pinging as fast as possible in narrowband mode, with 50 bins of 32 m each, and a 16 m blanking distance between transmit and receive. This configuration gives a maximum depth range of 1600 m, but the real operational range is about 1400 m. For most of the cruise, this allowed measurements over the full water column. The effective interval between consecutive pings was 3.05 s. The setup is documented in the following command file, sent by VmDas to the deck unit to start pinging:

```
; ADCP Command File for use with VmDas software.
; ADCP type:     38 Khz Ocean Surveyor
; Setup name:    MERIAN
; Setup type:    32m depth resolution, long range profile (narrowband)
;--------------------------------------------------------------------------/
; Restore factory default settings in the ADCP
cr1
; Set the data collection baud rate to 115200 bps,
; no parity, one stop bit, 8 data bits
; NOTE:  VmDas sends baud rate change command after all other commands in
; this file, so that it is not made permanent by a CK command.
cb711
; Disable single-ping bottom track
BP000
; Disable broadband Pings profile mode
WP000
; Set for narrowband profile mode, single-ping ensembles (NP),
; 50 bins (NN) of 32 meter length (NS), 16 meter blanking distance (NF)
NP001
NN050
NS3200
NF1600
; Output velocity, correlation, echo intensity, percent good
ND111100000
; Ping as fast as possible
TP000000
; Set to calculate speed-of-sound, no depth sensor,
; external synchro heading sensor, use internal
; transducer temperature
EZ1020001
; Set transducer misalignment (hundredths of degrees)
EA00000
; Output beam data (rotations are done in software)
EX00000
; Set transducer depth to 6.0 meters
ED00060
; Save this setup to non-volatile memory in the ADCP
CK
```

The 75 kHz instrument was started with a similar configuration, except for the number and size of the velocity averaging bins, in this case 100 bins of 8 m each, with a 4 m blanking distance. The achieved pinging interval was 2.64 s. The following command file was used to start the instrument:

```
; ADCP Command File for use with VmDas software.
; ADCP type:    75 Khz Ocean Surveyor
; Setup name:   MERIAN 21/1
; Setup type:   8m depth resolution, narrowband (long range) mode
;----------------------------------------------------------------------/
; Restore factory default settings in the ADCP
cr1
; Set the data collection baud rate to 115200 bps,
; no parity, one stop bit, 8 data bits
; NOTE:  VmDas sends baud rate change command after all other commands in
; this file, so that it is not made permanent by a CK command.
cb711
; Disable single-ping bottom track
BP000
; Disable broadband Pings profile mode
WP000
; Set for narrowband profile mode, single-ping ensembles (WP),
; 100 bins (WN) of 8 m length (WS), 4 meter blanking distance (WF)
NP001
NN100
NS0800
NF0400
; Output velocity, correlation, echo intensity, percent good
WD111100000
; Ping as fast as possible
TP000000
; Set to calculate speed-of-sound, no depth sensor,
; external synchro heading sensor, use internal
; transducer temperature
EZ1020001
; Output beam data (rotations are done in software)
EX00000
; Set transducer misalignment (hundredths of degrees)
EA04500
; Set transducer depth to 6.0 meters
ED00060
; Save this setup to non-volatile memory in the ADCP
CK
```

The misalignment angles given in the command files are approximate values. Even small misalignment errors can lead to noticeable errors in the velocities measured during steaming, due to the projection of the ship's speed. The actual misalignment for each instrument is determined statistically during data processing.

5.3.2 Navigation data

Navigation data was broadcast from the ship's systems to both dedicated PCs, and was collected using VmDas and integrated into the ADCP dataset. The primary source was the Kongsberg Seapath 200 GPS, which has an accuracy of 0.7--1.5 m for position, 0.075° for true heading and 0.03° for both pitch and roll. As a backup, positional data from a Trimble SPS461 DGPS was also collected.

5.3.3 Data quality and interference with other acoustics

As an intermediate step between data collecting and processing, data quality was regularly controlled using the WinADCP software, version 1.14, to check echo intensity and correlation levels for signs of signal degradation or interference from other acoustic systems on board. This control is particularly important after operations during which such auxiliary systems are required by the bridge, to ensure that they do not affect the data any more than strictly necessary.

During the previous leg of the cruise, it had been established that the Atlas DOLOG 22 (79 kHz) and the Kongsberg EA600 echo sounder (three channels: 12, 38 and 200 kHz) were sources of interference for the 75 kHz ADCP. Use of those systems was kept to a minimum also during this leg. Interference was also observed on this trip with the AUV transponders, and the ADCPs were usually switched off when within their range so as not to degrade AUV communications. Also during mooring releases and PIES data read-out operations, the ADCPs were switched off to minimize background noise.

5.3.4 Processing and preliminary results

The ADCP data was split into chunks each about 2 days long, backed up to the main data server and processed using OSSI, version 1.7, a Matlab toolbox developed at GEOMAR, Kiel. The navigational data integrated by VmDas in the ENX files was used, and 10 minute average velocities calculated for preliminary use, e.g. referencing of LADCP profiles. The averaged velocities from both instruments were detided using the Tide Model Driver (TMD) Matlab toolbox to calculate tidal velocities with TPXO, version 7.2, a global tidal model with 1/4° x 1/4° resolution; both TPXO and TMD are developed at Oregon State University. The VADCP measurements proved to be very useful to interpret the hydrographic sections carried out across Denmark Strait and near the main working area (white lines Figs. 4.1 and 4.2).

Fig. 5.7 below shows the detided velocities from the 75 KHz ADCP across Denmark Strait (along-section and across-section velocities are displayed in the upper and lower panels, respectively). Coinciding with the subsurface occurrence of warm and saline waters of Atlantic origin north of the front (i.e., on the Greenland side; Fig. 5.1), the velocity measurements show a pronounced inflow into the Atlantic being opposed by strong outflows south of the front. This eddy-like feature may draw from the Atlantic water volume on the southern side and advect it along its periphery so that the high-salinity / warm signal reappears on its periphery on the northern side. The strongest inflow velocities (found 60 km from the northern starting point of the section), however, appear coincide with significantly less saline and colder waters. Unfortunately, signal contamination (see discussion in 5.3.1) below about 400 m prevented good quality measurements of the near-bottom overflow core velocity. This means that the 75 KHz instrument did not provide a satisfactory coverage of the overflow waters (see Fig. 5.1).

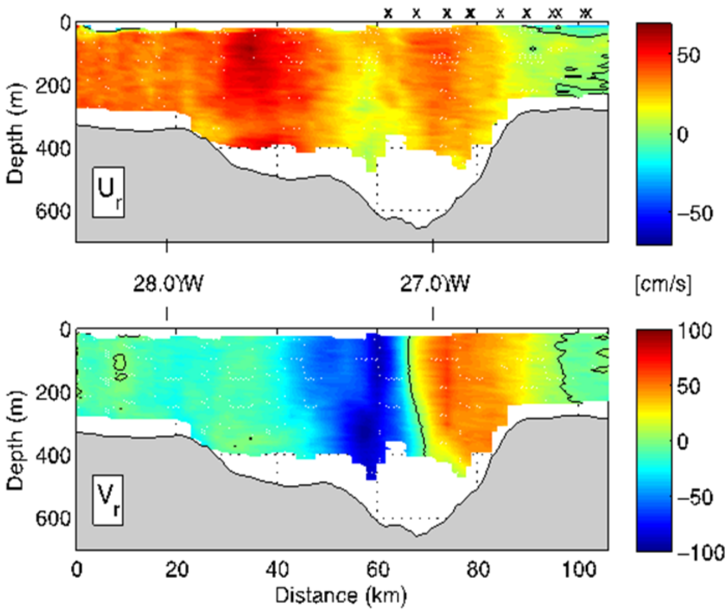


Fig. 5.7: Rotated velocities (75 kHz) on a section across Denmark Strait. U_r and V_r are the along- and cross-section components, respectively. The null velocity isotach is show in black. The nearly vertical separation between inflow (red) and outflow (blue) on the Icelandic and Greenlandic sides, respectively, is clearly seen in the V_r component

5.4 Profiling Microstructure

(Vadim Paka)

5.4.1 System and operation

Microstructure measurements were made by the experimental microstructure sonde (MSS) following the technique developed at the MSM 12-1 cruise in 2009. During preparation to the MSM 21-1b cruise some important changes aimed to improve data quality were made. The set of probes was changed: in addition to home-made shear probes a professionally made and calibrated sensor produced by Dr. Hartmuth Prandke was used as the reference one. Instead of the copper wire thermometer, which was not fast enough, the FP07 thermistor with the time constant of 7 ms was installed. Instead of the slow RC 232 interface the replaceable flash memory card providing almost immediate data downloading was used. This enables shortening the time necessary for the preparation to repeated profiling down to 60 min, which were spent for operations with recovery the 550 m long tether and placing it into the probe's interior. Previously, the tether length was about 400 m, and it was enlarged to increase of the thickness of the layer crossed during free falling regime. The probe was reduced in size and some heavy details used for its fastening to the Rosette were removed, so new fastening / releasing system became necessary. This task needed valuable time, which was not planned, but was taken from the main time of measurements. In **Fig. 5.8** the MMS attached to the CTD frame is shown.

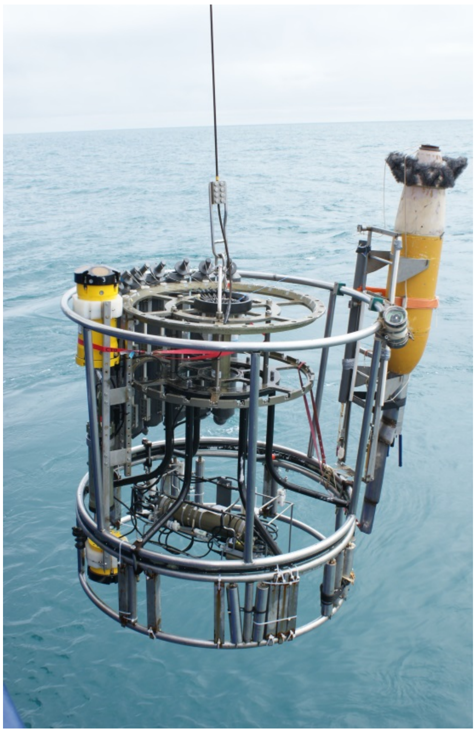


Fig. 5.8: Lowering of Baklan Microstructure probe (MSS) attached to the Rosette frame. The MSS represents a development of Vadim Paka and Vladimir Baranov (SIO,

Parts of the measurements were spoiled due to imperfection of the new releasing system. These data were excluded from scientific analysis. At all, acceptable for analysis were acquired data from 22 casts, 3 of these (CTD casts 101, 106, 159) presented the microstructure of the upper layer, while the rest 19 casts corresponded to the main task of the cruise – the study of the active 300m - thick bottom layer (see Table 5.3). Most of deep profiles reached the bottom. Both the data quality and the number of informative casts represent an improvement to previous results.

5.4.2 Preliminary results

Fig. 5.9 shows an example of obtained data (cast No. 148). The MSS was released at the altitude about 350 m above the bottom, while the upper boundary of the interfacial zone of the gravity current began ≈100 m deeper. The MSS reached the bottom, so both the irregularly stratified 180 m thick interfacial, or entrainment zone and the well mixed 90 m thick bottom boundary layer.

Calculated salinity and density profiles reveal a spiking contamination, while measured temperature and conductivity profiles are free from such contamination and reveal the real scalar microstructure. Turbulent intensity was measured by the shear probe. It was well correlated with the scalar microstructure within the interfacial zone and unusually strong and homogeneous within the bottom mixed layer. Such measurements provides estimating of the entrainment velocity $w_e \equiv \partial H / \partial t$ where H is a thickness of the gravity current as $w_e = 2\int_0^\infty K_\rho N^2 dz / \int_0^\infty g^* dz$ where the vertical eddy diffusivity of mass K_ρ is calculated from the measured quantities (ε, N^2). The mean values of the entrainment ratio and the Froude number $E = \frac{w_e}{U}$, $\mathrm{Fr} = \frac{U}{(B\,H)^{1/2}}$ are $E = 5.0\times10^{-5}$, $\mathrm{Fr} = 0.89$ (at the central 1450-m site) and $E = 3.7\times10^{-4}$, $\mathrm{Fr} = 0.71$ (at the southern 1760-m site at the offshore edge of the DSO plume). B and g* denote bulk buoyancy and reduced gravity, respectively.

Table 5.3: List of casts, where microstructure measurements were successful and all plots of microstructure measurements acceptable for further scientific analysis.

CTD Station number	Date/Time of CTD	Date/Time of MSS	CTD depth interval	MSS depth interval
101	10 Jun 2012 13:31:10	20120610_133214	No CTD	50-250
106	10 Jun 2012 19:51:05	20120610_203308	488.000	10-180
117	12 Jun 2012 23:54:18	20120613_003358	1425.000	1125-1380
119	13 Jun 2012 04:40:54	20120613_051612	1426.00	1150-1450
120	13 Jun 2012 06:46:40	20120613_071922	1426.000	1150-1440
123	13 Jun 2012 19:56:40	20120613_203528	1762.000	1500-1800
124	13 Jun 2012 22:23:54	20120613_230912	1767.000	1490-1800
128	14 Jun 2012 09:54:12	20120614_102820	1470.000	1205-1490
129	14 Jun 2012 15:27:34	20120614_160542	1469.000	1175-1425
130	14 Jun 2012 17:46:18	20120614_182224	1469.000	1175-1440
144	16 Jun 2012 09:07:28	20120616_094328	1434.000	1150-1460
145	16 Jun 2012 11:26:35	20120616_120228	1438.000	1160-1460
146	16 Jun 2012 14:28:40	20120616_151650	1439.000	1160-1355
158	18 Jun 2012 00:40:08	20120618_011454	1435.000	1150-1440
159	18 Jun 2012 03:01:11	20120618_041050	1436.000	20-340
160	18 Jun 2012 05:34:01	20120618_060756	1436.000	1100-1440
174	19 Jun 2012 07:27:56	20120619_080240	1434.000	1120-1455
178	19 Jun 2012 19:08:09	20120619_215908	1437.000	1120-1460
179	19 Jun 2012 21:24:59	20120620_002230	1436.000	1110-1455
180	19 Jun 2012 23:47:16	20120620_024358	1440.000	1120-1455
181	20 Jun 2012 02:08:30	20120620_024358	1441.000	1120-1455

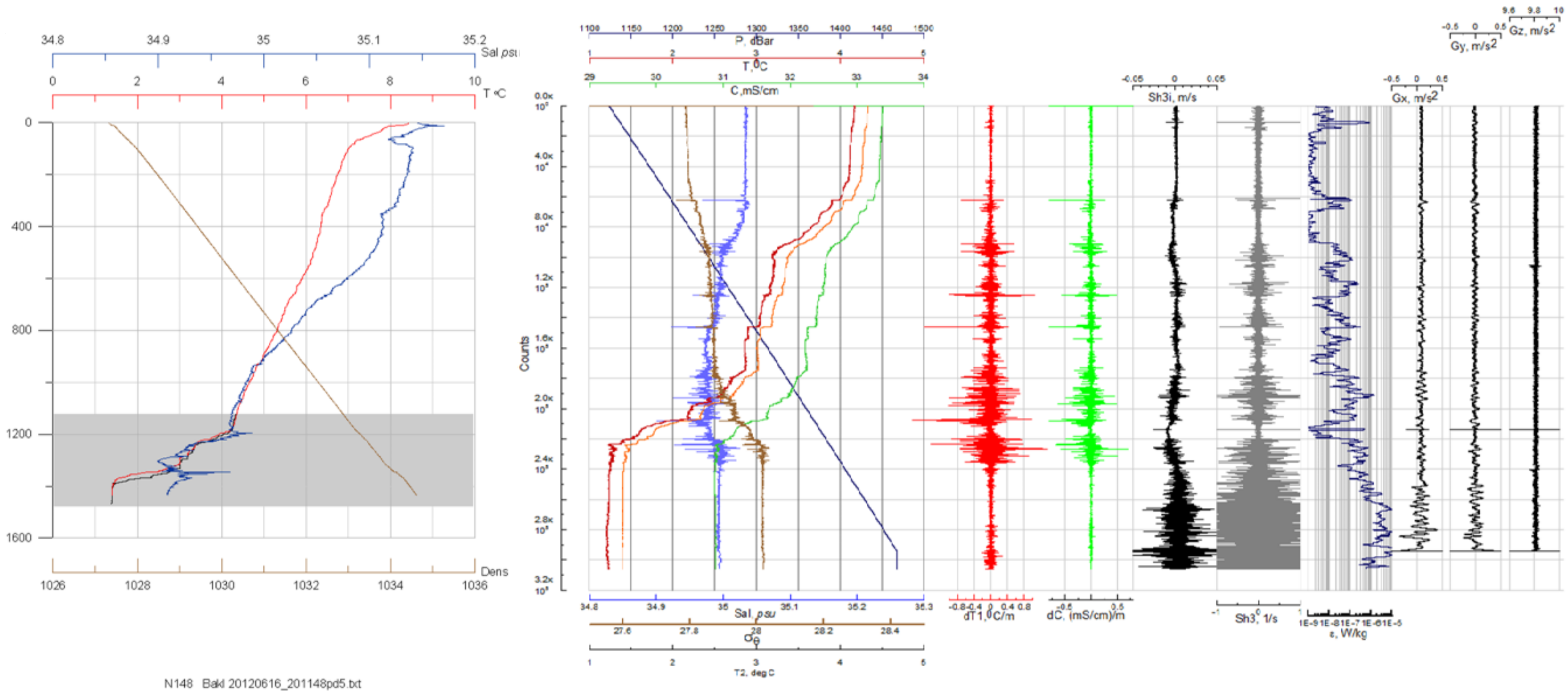
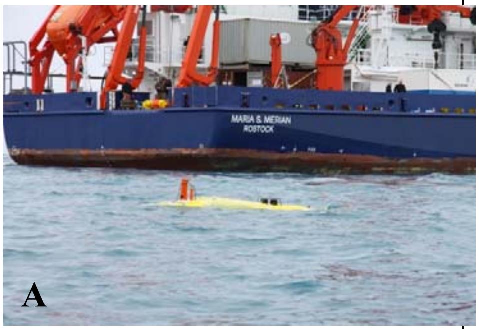
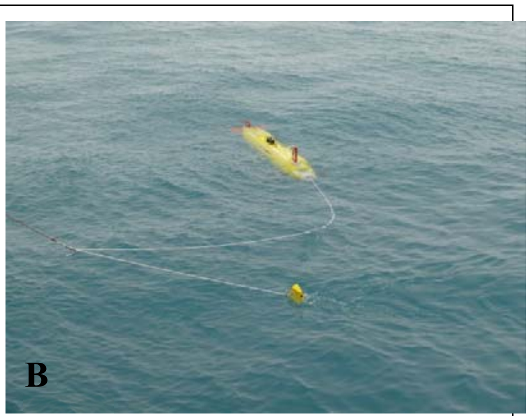


Fig. 5.9: Example of CTD/microstructure measurements at the station No. 148. Left combined panel: CTD temperature, salinity, and density & MSS temperature vs depth; MSS free falling depth interval is shadowed. Next combined panel to right: MSS depth p, precise temperature T2, conductivity C, salinity S, density $\sigma\theta$, and fast temperature T1 vs counts numbers. Next panels: temperature dT1 and conductivity dC gradients, transversal velocity signal Sh3i, shear velocity signal Sh3, turbulent kinetic energy dissipation rate ε, and 3 components accelerometer's signals Gx,Gy,Gz vs counts numbers.





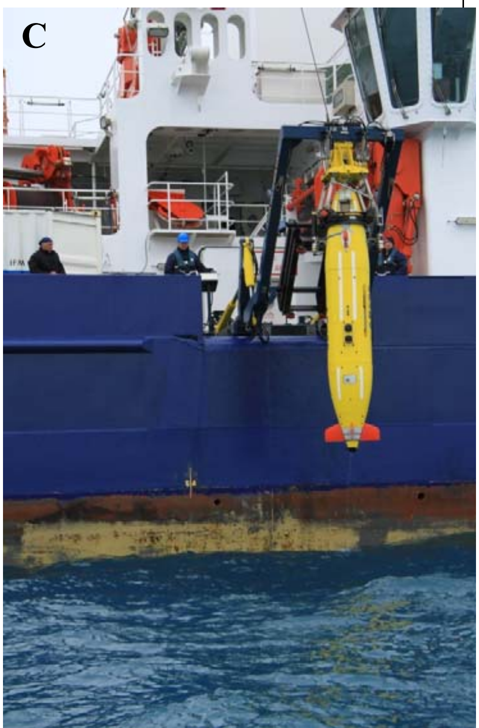


Fig. 5.10

A) AUV is emerged after a successful dive mission.

B) A grapnel hook snags the recovery line of the AUV.

C) The vehicle is pulled up in the LARS.

D) The deployment frame of the LARS is brought in and the AUV is safely secured.

5.5 AUV Measurements

5.5.1 System and Operations

(Klas Lackschewitz, Jan Sticklus, Marcel Rothenbek, Momme Deutschmann)

During MSM 21/1b, we deployed and recovered the AUV at weather conditions with a swell of up to 2.5 m and wind speeds of up to 6 Bft. After the completion of a dive mission the vehicle ascends to the surface with 0.7 to 0.9 kn. For the recovery the nose float pops off when triggered through an acoustic command. The float and the 20 m long recovery line drifts away from the vehicle so that a grapnel hook can snag the line (see **Fig. 5.10** B). The line is then connected to the LARS winch and the vehicle is pulled up (see **Fig. 5.10** C). Finally, the AUV is brought up on deck and safely secured in the LARS (see **Fig. 5.10** D). During MSM 21/1b no problems were encountered during any deployment or recovery with the LARS system.

The vehicle has navigated autonomously using a combination of navigation methods:
GPS determines the "initial position" before the vehicle submerges, and verifies or corrects the vehicle's position when it surfaces during the mission. GPS also plays a critical role during INS alignment. After alignment on the surface, INS continuously integrates acceleration in 3 axes to calculate the vehicle's position. It uses input from the Doppler Velocity Log (DVL) and the GPS to maintain its alignment. DVL continuously measures altitude and speed over ground whenever the vehicle can maintain bottom-lock. The DVL receives temperature and salinity data from the CTD Probe to calculate sound speed. The DVL must be within range of the bottom to measure altitude and provide bottom-lock for the INS.

The vehicle has also used the Long Baseline Acoustic Navigation (LBL) navigation by computing its range to three moored acoustic transponders. These three transponders were positioned in a row with a distance of app. 4000 m. The row was orientated upslope to ensure that the AUV is able to follow the contour lines (isobaths) inside the LBL net. The transponder calibration showed a remarkable drift offset of between 250 and 500 m.

For AUV mission summary see Appendix B.

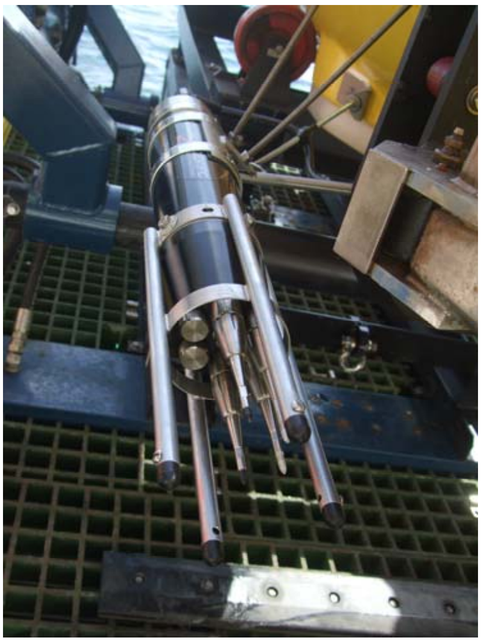


Fig. 5.11 MicroRider with shear and fast temperature sensors attached to the AUV Abyss.

5.5.2 AUV Microstructure – System and Operation

(Sandra Tippenhauer)

A MicroRider 6000 (MR) horizontal microstructure profiler from Rockland Scientific was mounted on the Remus 6000 AUV Abyss (**Fig. 5.11**). The MR is specifically adapted for the use on the AUV and the mounting brackets were designed such, that the instrument would fit inside the LARS for launch and recovery purposes. Our custom made MR consists of two pressure cases, with one housing the sensor electronics and the other the data recording unit. Power (24V) is supplied by the AUV, but data is stored internally in the MR.

The MR is used to estimate the rate of dissipation of turbulent kinetic energy. For this the MR is equipped with 2 velocity microstructure shear probes and 2 fast response temperature probes. It also accommodates a 3-axis accelerometer (to remove platform vibration contamination from the shear measurements) and a pressure sensor. The MR is operated with a sampling rate of 512 Hz.

In the following details of the MR deployments aboard AUV Abyss will be given. Table 5.4 gives time, mission durations and position, dive ID, sensor ID and orientation and data file name. Table 5.5 specifies the calibration coefficients for the shear probes.

Table 5.4: Overview over the MicroRider configuration during the different dives. Shear probe orientation shows the orientation of the plain metal area where the serial number is engraved. This plane is perpendicular to the sensitive axis of the probe.

Dive ID / AUV ID	**Launch date**	**Launch / recovery time**	**Duration [hh:mm]**	**Lat [N] / Lon [W]**	**Shear sensor # and S1 / S2 orientation**	**Temp. sensor # T1 / T2**	**Data file name [*.P]**
01 / 90	09.06. 2012	11:13 / 14:26	03:13	64°21.15 22°25.48	M845 -- M709 --	T628 T629	DAT048
02 / 91	12.06. 2012	22:01 / 11:11	13:10	65°12.80 29°57.99	M845 -- M844 --	T628 T629	DAT049
03 / 92	14.06. 2012	11:41 / 22:20	10:39	65°13.13 29°57.12	M845 -- M844 --	T628 T629	DAT050
04 / 93	16.06. 2012	08:07 / 08:29	00:22	65°13.20 29°57.52	M845 -- M844 --	T628 T629	DAT051
05 / 94	16.06. 2012	13:20 / 02:44	13:24	65°12.99 29°57.40	M844 -- M845 --	T628 T629	DAT052
06 / 95	17.06. 2012	18:34 / 08:25	13:51	65°13.56 29°55.20	M844 | M845 --	T628 T629	DAT053
07 / 96	18.06. 2012	22:46 / 13:16	14:30	65°14.14 29°55.21	M844 | M845 |	T628 T629	DAT054
08 / 97	20.06. 2012	06:06 / 07:49	01:45	65°13.06 29°58.33	M844 | M840 |	T628 T629	DAT055
09 / 98	20.06. 2012	09:14 / 16:06	06:52	65°12.97 29°58.07	M839 | M840 |	T628 T629	DAT056

Table 5.5: Calibration coefficients of the MicroRider shear probes used during MSM21/1b.

Shear Sensor #	**M709**	**M839**	**M840**	**M844**	**M845**
Sensitivity [V/(m/s) ²]	0.0617	0.0763	0.0677	0.0601	0.0661
Total Gain	1	1	1	1	1

Specific comments to the different dives:

Dive 1: Test dive offshore Iceland to verify both the function of the AUV multibeam echosounder and the general status of the AUV. The MR worked fine. Sensor M709 showed a 180° phase shift and smaller amplitude compared to the M845 sensor. Because sensor M845 is the newer one, we exchanged the M709.

Dive 2: In this dive the AUV was supposed to stay on one (depth-contour-following) ground track while carrying out measurements at 6 depth levels. The mission was aborted shortly before nominal mission end due to low battery. The AUV was not enabled to accept LBL positions.

Dive 3: Aborted on the first leg to northeast due to strong counter currents and timeout. The planned track consisted of 4 parallel along current lags of app. 4 km length. At the end of each along current leg followed a shorter leg of 1 km length perpendicular to the current, followed by the next along current leg. The resulting mattress was supposed to be occupied 3 times, each time in a different altitude. To test the AUV behavior on a longer track perpendicular to the current, a 3 km long segment at the end of the 3rd mattress back to the first waypoint was carried out. The AUV was not enabled to accept LBL positions.

Dive 4: Based on the timeout experience in dive 3 we planned a slightly different track to minimize the counter current legs. On counter current segments the AUV was supposed to ascent to 200 m above sea floor (i.e. above the DSOW plume) where the current was much weaker. The connecting segments originally planned perpendicular to the current were modified such that the AUV would go diagonal to but with the current. However the dive was aborted due to a leak message just as the vehicle started the drive descent mode. The AUV was not enabled to accept LBL positions.

Dive 5: Same track as planned for dive 4. Mission completed successfully. The AUV was enabled to accept LBL positions.

Dive 6: This dive followed only one track which was occupied at different depth levels in the direction of the mean DSOW flow near the DSOW plume – ambient water – interface. On counter current segments the AUV ascended to 200 m above sea floor where the current was much weaker (i.e. above the DSOW plume). At the end of the dive the AUV followed a spiral track while ascending and descending to test the behavior of the shear probe in a situation with more or less permanent changing strong currents. Before the dive one of the shear probes was turned by an angle of 90° to test whether the vibrations differ in the different planes. The vibration seemed to be less in the “new” direction (probe oriented vertical). From this dive on both probes were mounted vertically. The AUV was enabled to accept LBL positions.

Dive 7: Dive 7 was planned to be similar to dive 4 and 5 but with shorter along current segments in favor of one more parallel segment. At the end of the dive the AUV was supposed to enter the loiter mode but due to a leak message the Mission aborted shortly after the beginning of this mode. The AUV was enabled to accept LBL positions. Possibly, there was a collision with some algae, as threads were found on the shear probe upon recovery. Data from one of the shear probes (M845) looked suspicious (showing a significantly smaller shear signals than probe M844). Probe M845 was replaced for the next dive.

Dive 8: The AUV was supposed to stay on a fixed altitude and go as long as possible in counter current direction. The position of the AUV is less well known after the time the AUV leaves the range of the transponders. The vessel was supposed to follow the AUV in order to maintain communication. Unfortunately, the mission was aborted due to timeout before the AUV reached the first waypoint of the (scientific) track.

Dive 9: Track planned as for dive 8. Between waypoint 9 and 10 the vehicle received the command from the vessel to return to the surface. We had to steam back to Reykjavik. Before the dive one shear sensor had to be changed. While trying to change the orientation of the former sensor the metal case detached from the electronics inside the probe. During recovery of the sensors we spotted a piece of algae at the tip of the temperature sensor T2 (T629). In this dive we mounted the shear sensors vertically but antiparallel such that the serial numbers were looking in opposite direction. In all the other dives the shear probes were oriented parallel.

5.5.3 AUV microstructure - preliminary results

(Sandra Tippenhauer and Torsten Kanzow)

The raw velocity shear data show a high degree of noise caused by high-frequency vibrations of the AUV. To remove the noise, we use a filter developed by Goodman (2006). This filter removes the fraction of the shear signal which is coherent with the acceleration signal simultaneously measured by the MR. From this “cleaned” shear data we compute shear spectra of overlapping data segments, with a segment length of 2 seconds. The spectra are then integrated in a “trusted” wavenumber range. To account for the missing rest of the spectrum, the universal Nasmyth spectrum is fitted to the shear spectra and integrated over the missing wave number range. To account for losses due to the probe size the spectrum is corrected for high wave numbers. The dissipation rate is then computed by $\varepsilon = 7.5\ \nu < (dv/dx)^2 >$, with ν being the molecular viscosity of seawater.

The preliminary analyses show a decrease in dissipation of turbulent kinetic energy with increasing distance from the sea floor. At 1415 dbar (roughly 45 m above the sea floor), the average dissipation during dive 6 (second half, shown Fig. 5.5.3) is $4.0 \cdot 10^{-7}$ W kg^{-1}, while above the transition zone between the overflow plume and the overlying water and average value of only $1.4 \cdot 10^{-8}$ W kg^{-1} is found. (The latter value might be slightly biased high, because of the apparent noise level of about $0.8 \cdot 10^{-8}$ W kg^{-1}). Peak values of about $2 \cdot 10^{-6}$ W kg^{-1} are found at 1415 dbar. The reported range of values is in agreement with that obtained from the vertically profiling device (shown exemplarily in Fig. 5.9). Interestingly, during the first half of AUV dive 6 there was evidence for stronger current velocities of the overflow plume, which coincided with elevated levels of dissipation ($6.0 \cdot 10^{-7}$ W kg^{-1} at 1415 dbar; not shown).

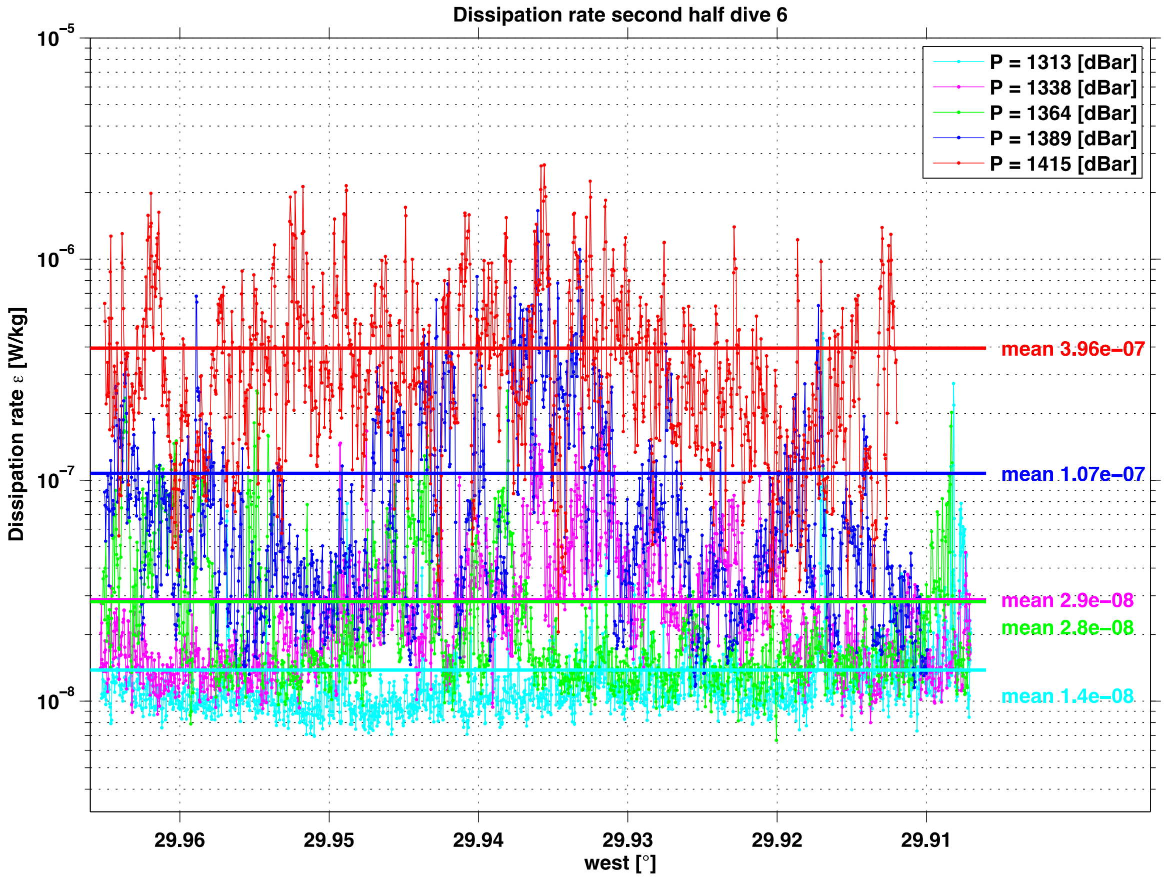


Fig. 5.12 Dissipation of turbulent kinetic energy from microstructure shear measurements aboard AUV Abyss during the second half of dive 6 (each value represents the average of two sensors). The different colours represent measurements on different pressure levels (see Fig. 5.13). All pressure levels were occupied along the same ground track. The colored horizontal lines represent the mean dissipation rates for the individual pressure levels.

5.5.4 AUV CTD

(Torsten Kanzow and Detlef Quadfasel)

During all of the AUV dives standard CTD measurements were carried out with the SEABIRD Fastcat SBE49. These data will be used to analyse scales of horizontal changes in the hydrographic properties of the DSOW plume and its transition to ambient Atlantic waters. The data shall further serve as guidance for the interpretation of the microstructure data recorded on the AUV. All dives reveal largely elevated levels of variability of temperature and salinity in the shear zone above the plume, when compared to conditions both within the plume and further away from the plume. This is nicely illustrated in dive #2 (AUV dive ID #91), the first dive that took place in the entrainment area (see **Fig. 5.13**).

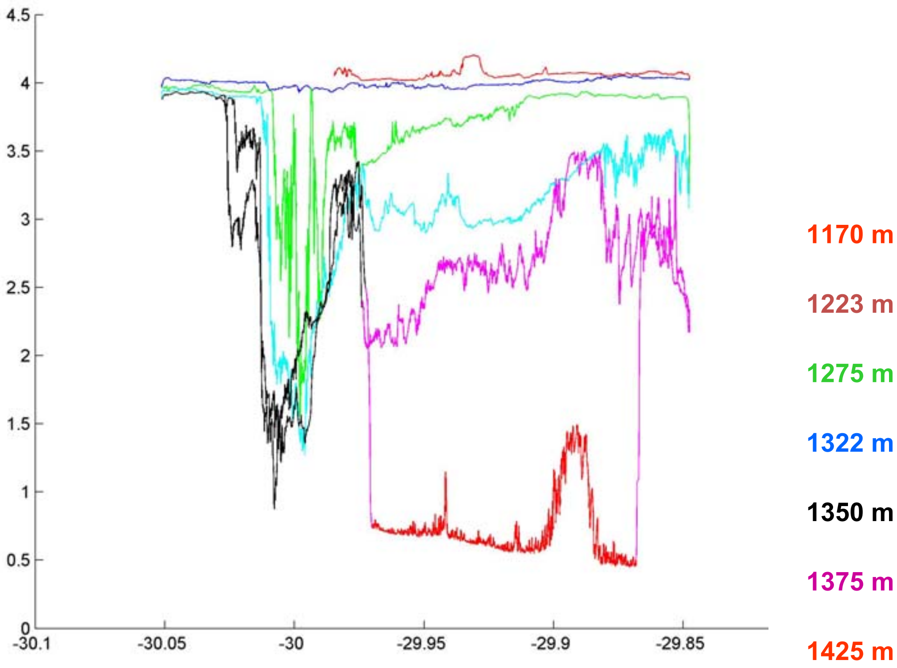


Fig. 5.13 In situ temperature [°C] as a function of geographic longitude [°E] recorded by the Seabird CTD package aboard AUV Abyss close to the site of the central mooring of the entrainment mooring cluster on different depth levels.

5.6 Underway hydrographic measurements
(Nadine Mengis)

5.6.1 System, operation and preliminary results

On board of R/V MARIA S. MERIAN during the research cruise MSM_021_1/b from June, 9th to June, 22th 2012 the central data distributer (DVS) continuously recorded a set of oceanographic and meteorological parameters from several sensors, including sea surface temperature (SST) and sea surface salinity (SSS) as well as meteorological parameters like wind speed, wind direction, air temperature and pressure and humidity. The sea surface salinity (SSS) and sea surface temperature (SST) were measured by a thermosalinograph (TSG; „Reinseewassersystem“). There are two separate measurement systems which alternatingly carry out measurements during 12 hour long intervals. The systems are cleaned and flushed while not active. This avoids biofouling while enabling continuous measurements. Each system comprises two sets salinity / temperature sensors, with one being located in the vessel's interior and at the vessel's seawater intake located at 6m depth. The temperature at the intake and the salinity measured inside are shown in Fig. 5.14 and **Fig. 5.15**. During the cruise there were no major problems with the TSG system.

During the cruise SST values ranged between 1.53°C to 10.49°C measured at the vessel's seawater intake. The temperatures measured inside the vessel are approximately 1.5°C higher due to warming in the ship. Lowest values of SST (intake) occurred near the Greenlandic coast, during the Denmark Strait section (see Fig. 5.14). This is due to the presence of the cold and fresh East

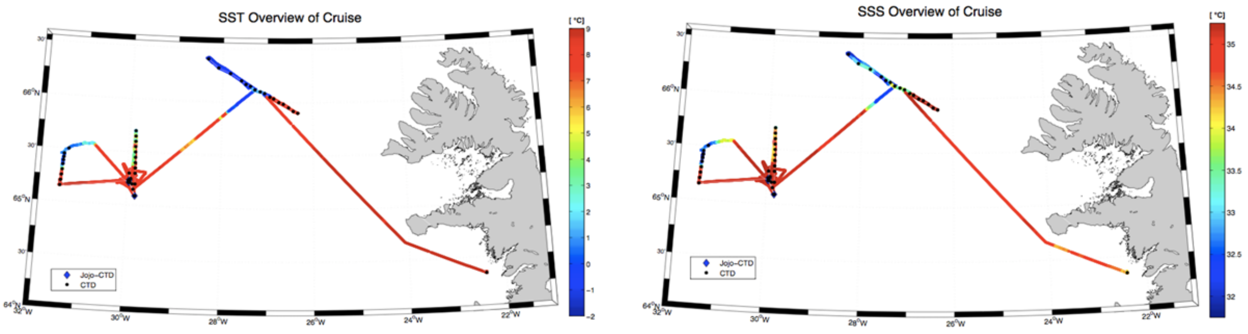


Fig. 5.14: Map of temperature (left) and salinity at the sea surface (right) of the vessel's thermosalinograph.

Greenland Current near the coast. The SSS values ranged between 31.73 to 35.22 psu, with the lowest values occurring on the Greenland side of the Denmark Strait section (see **Fig. 5.14**).

The comparison between the TSG data and measurements of the lowered CTD at 6 m depth showed an increasing variance toward the end of the cruise for temperature and a distinct offset for salinity (Fig. 5.15). This calculation is based on a temporal resolution of one second for both TSG and lowered CTD data sets. The temperature (salinity) difference between both systems was 0.041°C (0.008 psu). The standard deviation of the temperature (salinity) differences was 0.140°C (0.084 psu).

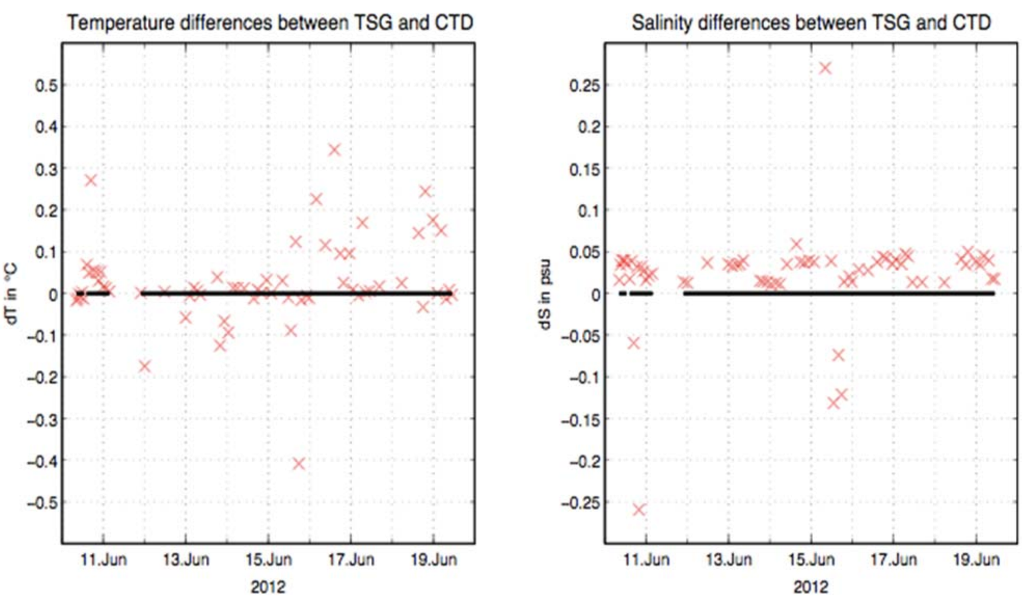


Fig. 5.15: Differences between TSG and lowered CTD measurement for SST (top) and SSS (bottom).

5.7 Moorings

(Detlef Quadfasel and Kerstin Jochumsen)

5.7.1 Recovered mooring DS-2 in Denmark Strait

Table 5.6: Recovered mooring DS-2 in Denmark Strait.

Mooring No.	Recovery date	Time UTC	Latitude	Longitude	Depth
DS02-11 ADCP	09.06.2012	18:24	66°07.23'N	027°16.19'W	571 m

Monitoring the Denmark Strait overflow has been an objective of several research programs. Two mooring positions at the sill of Denmark Strait have been occupied since 1996, with some mooring losses due to fishery or instrument failure. At the moment, mooring DS 1 is maintained by the Marine Research Institute in Reykjavik, Iceland, while mooring DS 2 is sustained by the University of Hamburg, Germany.

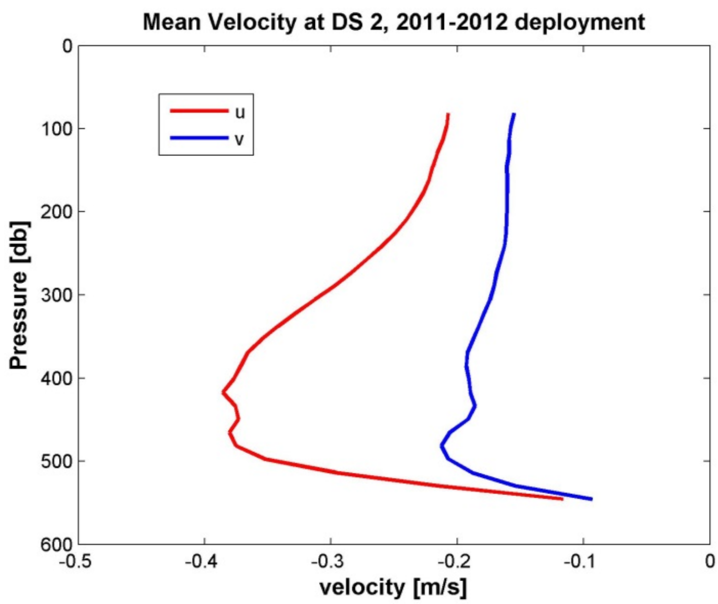


Fig. 5.16: Mean velocity at mooring DS 2. Red: East-west component (u), blue: north-south component (v). Negative velocities are westward and southward. The upper layer shallower than 80 m was out of the range of the instrument.

DS 2 was deployed in 2011 during the cruise M85-2 with R/V Meteor at 66°07, 23'N, 27°16, 19'W in 571 m depth on 21st of August. The mooring design was very short, to avoid long mooring lines which are more endangered by fishery: the release (SN 815, IXSEA Oceano) was 4 m above the anchor, directly attached to the release was a Seabird SBE37 MicroCAT (SN 4051), followed by a floatation buoy containing a Longranger 75 kHz ADCP (SN 13486, RD Instruments). The mooring was recovered during MSM 21-1b on 11th of June 2012.

The data quality of the moored instruments was good, and all records appear to be good time series. The velocity measurements show the core of the overflow at 400 m - 500 m depth (see **Fig. 5.16**). Overflow velocities sometimes exceed 1 m/s, but are close to 40 cm/s in the mean. The high variability of the overflow is also reflected in the near bottom temperature measurements (see **Fig. 5.**). Mooring DS-2 was redeployed during a cruise with R/V POSDEIDON in August 2012, as the monitoring of the Denmark Strait overflow is an on-going effort.

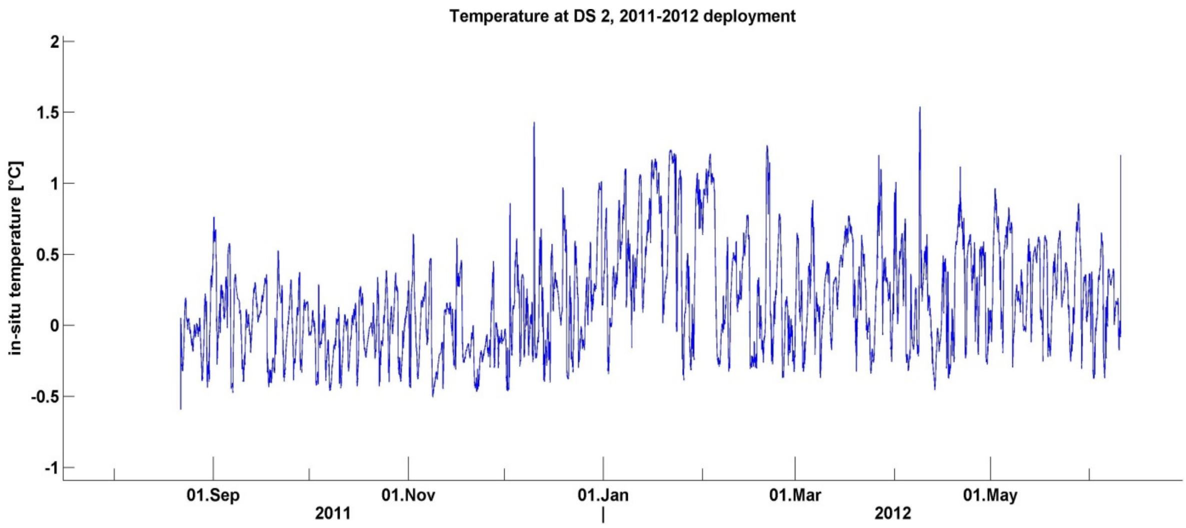


Fig. 5.17: In situ temperature [°C] as measured by the MicroCAT of DS 2.The temporal resolution is 10 minutes.

5.7.2 Deployments

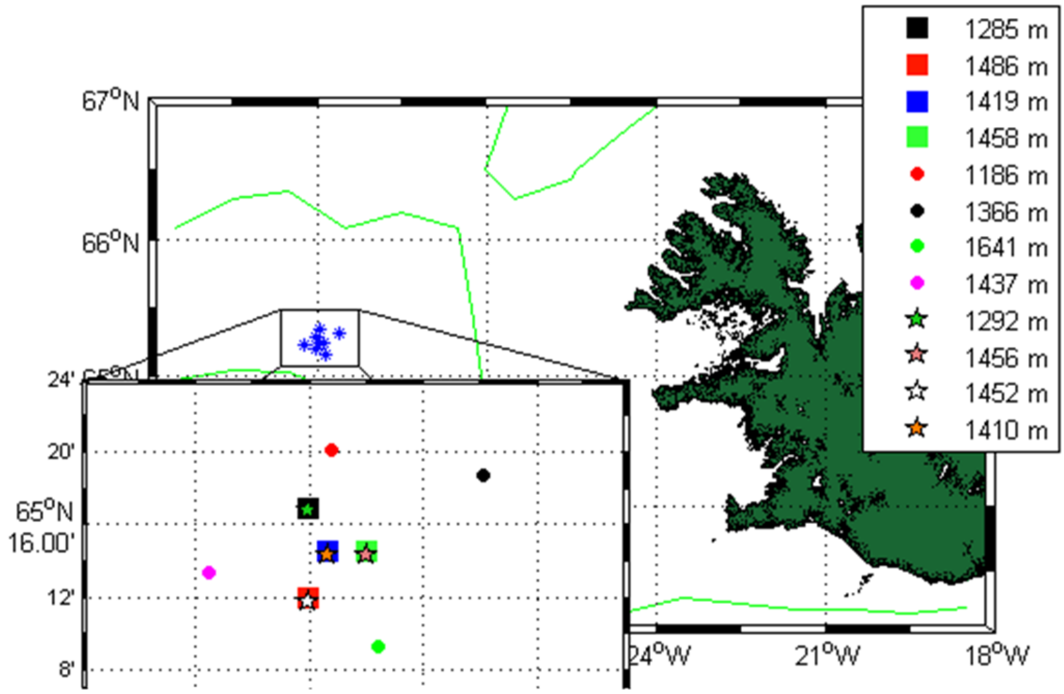


Fig. 5.18 Position of ADCP (squares), RCM (dots) and MC (stars) moorings. The different colors indicate the water depth of the moorings. For more detail see Table 5.7.

A total of 12 moorings were deployed in work area 2 (Figs. 4.1, 4.2, 5.17) between June 12 -16, of which the outer 4 (dots in Fig. 5.18) are equipped conventional near-bottom RCM current meters, while the inner eight represent pairs of ADCP / Microcat moorings (Fig. 5.18; shown squares and stars, respectively). The deployment of the mooring array was carried out according to plan; no problems were encountered. All moorings were recovered in August 2012 aboard R/V Poseidon.

Table 5.7: Numbers, deployment period, location and depth of ADCP, RCM and MC moorings.

Mooring No.	Deployment date	Time UTC	Latitude	Longitude	Depth
DS08 ADCP	12.06.2012	18:15	65°16.94'N	030°00.11'W	1285 m
DS09 ADCP	12.06.2012	19:15	65°11.97'N	030°00.10W	1486 m
DS10 ADCP	12.06.2012	19:58	65°14.51'N	029°57.51'W	1419m
DS11 ADCP	12.06.2012	20:40	65°14.51'N	029°52.35'W	1458m
DS12 RCM	13.06.2012	16:38	65°20.13'N	029°57.00'W	1186m
DS13 RCM	13.06.2012	15:23	65°18.71'N	029°37.20'W	1366m

Mooring No.	Deployment date	Time UTC	Latitude	Longitude	Depth
DS14 RCM	13.06.2012	14:00	65°09,30'N	029°51.00'W	1641m
DS15 RCM	13.06.2012	12:41	65°13,31'N	030°13.20'W	1437m
DS16 MC	14.06.2012	14:43	65°16,80'N	030°00.12'W	1292m
DS17 MC	14.06.2012	13:12	65°14,34'N	029°52.35'W	1456m
DS18 MC	14.06.2012	09:05	65°11,80'N	030°00.16'W	1452m
DS19 MC	16.06.2012	07:21	65°14,34'N	029°57.51'W	1410m

ADCP - acoustic Doppler Current profiler and Microcat
RCM - Aanderaa Currentmeter and Microcat
MC - Microcats, temperature recorders; in DS19 also current meters (Aquadopp and ADCP)

5.8 PIES Telemetry

(Kerstin Jochumsen)

Two pressure inverted echo sounder (PIES) owned by the University of Hamburg were deployed in Denmark Strait on the cruise M85-2 in 2011. The batteries within the PIES last for approx. four years, therefore the PIES were not recovered during MSM 21-1b. Nevertheless, data acquisition from the instruments is possible by acoustic telemetry and was attempted using a hydrophone and a deckunit. The hydrophone (Benthos model XTD-LF, SN 202) was attached to a 150 m cable and hence lowered to depth well below the ship´s hull. A Benthos DS-7000 deckunit (SN 229) was used to communicate with the PIES. Since the deckunit must be run on battery during the telemetry, a fast power supply (SRM 1000, 250 W) device was attached to the unit to ensure a stable power supply. A standard windows laptop was connected to the deckunit for data acquisition, which was performed by a matlab program. Hydrophone and deckunit were kindly provided by the University of Bremen.

PIES #270 (instrument type 6.2B) was reached at 3:05 UTC on Sunday, 10th of June. Communication was established at 3:43 UTC and the data recording started. On two remote channels of the deckunit false settings were initially used, therefore the data acquisition was stopped at 4:05 UTC and restarted at 4:07 UTC. Few data was acquired on channel 2, but increasing the gain of the channel resulted in no improvements. Data acquisition was finished at 5:45 UTC.

MS MERIAN reached PIES #269 (instrument type 6.2B as well) at 9:35 UTC on Monday, 11th of June. Communication with the PIES was established at 10:05 UTC and the data recording started at 10:17 UTC. Again, few data was acquired on channel 2, but increasing the gain of the channel resulted in no improvements. Data acquisition was finished at 12:25 UTC. Some attempts were made to communicate with the PIES using the newer Benthos deckunit type UDB-9000-M (SN 54358), but failed.

Processing of the telemetry records showed that data was missing on all channels for both PIES. Gaps were most pronounced in the pressure data, acquired on channel 2. Interference with acoustic noise from the ship can be ruled out as a source for errors, as the hydrophone was well below the ship and in very quiet water. More likely, the distance between the hydrophone and the PIES was too short (approx. 450-500 m) to allow a wide sound cone and some pings were out of reach of the hydrophone. Another attempt on data acquisition by telemetry will be carried out on a subsequent cruise on R/V POSDEIDON with a hydrophone on a shorter cable and increased gain of the deckunit.

6 Ship's Meteorological Station

Throughout the cruise we mainly encountered rather stable and calm meteorological conditions. We experienced southerly to easterly winds with wind speed mainly staying mostly below 4 Bft. Only on two occasions (9 June and 18 June) wind speeds of 6 Bft. were reached. These conditions were certainly favorable for the success of our cruise, because they allowed us to launch and recover the AUV any time it was required. It also meant that the mooring and CTD operations could be conducted smoothly without weather-related delays. The presence of dense sea ice on the Greenland shelf encountered both in Denmark Strait and in the main work area, however, did not allow us to extend the cross-slope hydrographic sections far onto the shelf.

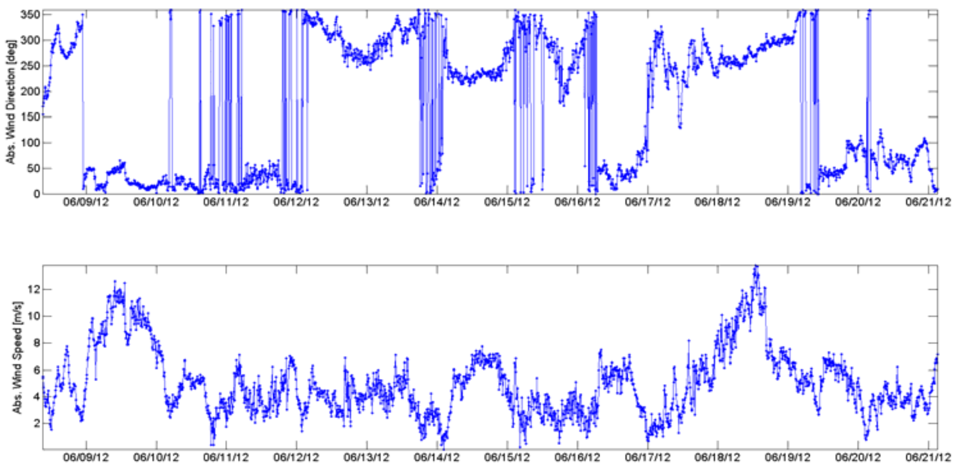


Fig. 6.1 Time series of absolute wind direction in deg (top) and speed in m/s (bottom) during the cruise.

7 Station List MSM21/1b

EXP. CODE	Stat No.	Cast No.	Type	Date dd.mm.yyyy	Time UTC-Code		Position Latitude	Longitude	Bottom depth	Max. depth	Bottom dist.	Comments
MSM21/1b	300	1	RO/CTD/ADCP	09.06.2012	13:00	BE	64° 21.06' N	22° 24.67' W	65.0			Test CTD
MSM21/1b	300	1	RO/CTD/ADCP	09.06.2012	13:02	BO	64° 21.05' N	22° 24.72' W	65.0	55	9	Test CTD
MSM21/1b	300	1	RO/CTD/ADCP	09.06.2012	13:08	EN	64° 21.06' N	22° 24.67' W	65.0			
MSM21/1b	301	1	PIES	10.06.2012	03:09	BE	66° 4.58' N	27° 4.87' W	1322.2			Hydrophone
MSM21/1b	301	1	PIES	10.06.2012	06:23	EN	66° 4.57' N	27° 4.91' W	1360.6			Hydrophone on deck
MSM21/1b	302	1	RO/CTD/ADCP	10.06.2012	08:22	BE	65° 53.97' N	26° 20.06' W	283			LADCP #680 installed
MSM21/1b	302	1	RO/CTD/ADCP	10.06.2012	08:32	BO	65° 53.97' N	26° 20.05' W		277	8	
MSM21/1b	302	1	RO/CTD/ADCP	10.06.2012	08:42	EN	65° 53.97' N	26° 20.05' W	1679.7			
MSM21/1b	303	1	RO/CTD/ADCP	10.06.2012	09:06	BE	65° 54.99' N	26° 26.07' W	282.6			
MSM21/1b	303	1	RO/CTD/ADCP	10.06.2012	09:15	BO	65° 54.99' N	26° 26.07' W		274	9	
MSM21/1b	303	1	RO/CTD/ADCP	10.06.2012	09:25	EN	65° 54.99' N	26° 26.07' W	0			
MSM21/1b	304	1	RO/CTD/ADCP	10.06.2012	09:50	BE	65° 57.01' N	26° 32.20' W	286			
MSM21/1b	304	1	RO/CTD/ADCP	10.06.2012	09:59	BO	65° 57.01' N	26° 32.20' W		279	8	
MSM21/1b	304	1	RO/CTD/ADCP	10.06.2012	10:10	EN	65° 57.01' N	26° 32.20' W	0			
MSM21/1b	305	1	RO/CTD/ADCP	10.06.2012	10:54	BE	65° 59.02' N	26° 39.18' W	285.5			
MSM21/1b	305	1	RO/CTD/ADCP	10.06.2012	11:03	BO	65° 59.02' N	26° 39.18' W		276	10	
MSM21/1b	305	1	RO/CTD/ADCP	10.06.2012	11:13	EN	65° 59.03' N	26° 39.19' W	0			
MSM21/1b	306	1	RO/CTD/ADCP	10.06.2012	11:39	BE	66° 0.01' N	26° 45.16' W	371.9			
MSM21/1b	306	1	RO/CTD/ADCP	10.06.2012	11:49	BO	66° 0.03' N	26° 45.20' W		363	9	
MSM21/1b	306	1	RO/CTD/ADCP	10.06.2012	12:00	EN	66° 0.13' N	26° 45.12' W	1650.7			
MSM21/1b	307	1	RO/CTD/ADCP	10.06.2012	12:29	BE	66° 2.00' N	26° 52.01' W	539			
MSM21/1b	307	1	RO/CTD/ADCP	10.06.2012	12:42	BO	66° 2.10' N	26° 51.88' W		527	9	
MSM21/1b	307	1	RO/CTD/ADCP	10.06.2012	12:57	EN	66° 2.25' N	26° 51.72' W				
MSM21/1b	308	1	RO/CTD/ADCP	10.06.2012	13:33	BE	66° 2.99' N	26° 57.04' W	596.0			W/MSS. Aborted. (MSS)
MSM21/1b	308	1	RO/CTD/ADCP	10.06.2012	13:35	BO	66° 2.99' N	26° 57.04' W				W/MSS. Aborted. (MSS)

EXP. CODE	Stat No.	Cast No.	Type	Date dd.mm.yyyy	Time UTC-Code		Position Latitude	Longitude	Bottom depth	Max. depth	Bottom dist.	Comments
MSM21/1b	308	1	RO/CTD/ADCP	10.06.2012	14:02	EN	66° 3.21' N	26° 57.02' W				W/MSS. Aborted. (MSS)
EXPO	Stat	Cast		Date	Time		Position		Bottom	Max.	Bottom	Comments
CODE	No.	No.	Type	dd.mm.yyyy	UTC-Code		Latitude	Longitude	depth	depth	dist.	
MSM21/1b	308	2	RO/CTD/ADCP	10.06.2012	14:26	BE	66° 3.00' N	26° 57.03' W	596			
MSM21/1b	308	2	RO/CTD/ADCP	10.06.2012	14:42	BO	66° 3.19' N	26° 56.92' W		592	4	
MSM21/1b	308	2	RO/CTD/ADCP	10.06.2012	14:58	EN	66° 3.35' N	26° 56.71' W	0			
MSM21/1b	309	1	RO/CTD/ADCP	10.06.2012	15:38	BE	66° 5.00' N	27° 4.01' W	660			
MSM21/1b	309	1	RO/CTD/ADCP	10.06.2012	15:56	BO	66° 5.02' N	27° 3.99' W		647	7	
MSM21/1b	309	1	RO/CTD/ADCP	10.06.2012	16:15	EN	66° 5.09' N	27° 3.93' W	0			
MSM21/1b	310	1	RO/CTD/ADCP	10.06.2012	16:47	BE	66° 5.98' N	27° 9.95' W	631.2			
MSM21/1b	310	1	RO/CTD/ADCP	10.06.2012	17:05	BO	66° 5.89' N	27° 10.06' W		623	9	
MSM21/1b	310	1	RO/CTD/ADCP	10.06.2012	17:21	EN	66° 5.73' N	27° 10.30' W	0			
MSM21/1b	311	1	BOTTOM ADCP	10.06.2012	17:55	BE	66° 6.83' N	27° 16.74' W				Hydrophone
MSM21/1b	311	1	BOTTOM ADCP	10.06.2012	18:24	EN	66° 6.52' N	27° 17.01' W				Hydrophone
MSM21/1b	312	1	RO/CTD/ADCP	10.06.2012	18:40	BE	66° 6.95' N	27° 17.07' W	577.6			
MSM21/1b	312	1	RO/CTD/ADCP	10.06.2012	18:56	BO	66° 6.79' N	27° 17.35' W		570	11	
MSM21/1b	312	1	RO/CTD/ADCP	10.06.2012	19:13	EN	66° 6.46' N	27° 17.80' W	0			
MSM21/1b	313	1	RO/CTD/ADCP	10.06.2012	19:47	BE	66° 8.96' N	27° 23.04' W	514.7			w/MSS. (failed)
MSM21/1b	313	1	RO/CTD/ADCP	10.06.2012	20:01	BO	66° 8.75' N	27° 23.60' W		480	18	w/MSS. (failed)
MSM21/1b	313	1	RO/CTD/ADCP	10.06.2012	20:34	EN	66° 8.25' N	27° 24.32' W				w/MSS. (failed)
MSM21/1b	314	1	RO/CTD/ADCP	10.06.2012	21:21	BE	66° 9.97' N	27° 29.05' W	488			
MSM21/1b	314	1	RO/CTD/ADCP	10.06.2012	21:34	BO	66° 9.84' N	27° 29.34' W		474	9	
MSM21/1b	314	1	RO/CTD/ADCP	10.06.2012	21:47	EN	66° 9.66' N	27° 29.63' W				
MSM21/1b	315	1	RO/CTD/ADCP	10.06.2012	22:23	BE	66° 11.96' N	27° 35.05' W	489.5			
MSM21/1b	315	1	RO/CTD/ADCP	10.06.2012	22:36	BO	66° 11.89' N	27° 35.10' W		477	10	
MSM21/1b	315	1	RO/CTD/ADCP	10.06.2012	22:47	EN	66° 11.76' N	27° 35.18' W				
MSM21/1b	316	1	RO/CTD/ADCP	10.06.2012	23:55	BE	66° 15.97' N	27° 49.93' W	461			

EXP. CODE	Stat No.	Cast No.	Type	Date dd.mm.yyyy	Time UTC-Code		Position Latitude	Longitude	Bottom depth	Max. depth	Bottom dist.	Comments
MSM21/1b	316	1	RO/CTD/ADCP	11.06.2012	00:07	BO	66° 15.97' N	27° 49.93' W		447	10	
MSM21/1b	316	1	RO/CTD/ADCP	11.06.2012	00:19	EN	66° 15.97' N	27° 49.93' W	0			
MSM21/1b	317	1	RO/CTD/ADCP	11.06.2012	01:26	BE	66° 18.98' N	28° 6.02' W	444.4			
MSM21/1b	317	1	RO/CTD/ADCP	11.06.2012	01:37	BO	66° 18.99' N	28° 6.02' W		332	10	
MSM21/1b	317	1	RO/CTD/ADCP	11.06.2012	01:46	EN	66° 18.99' N	28° 6.02' W	0			
MSM21/1b	318	1	RO/CTD/ADCP	11.06.2012	03:38	BE	66° 23.96' N	28° 20.01' W	330			
MSM21/1b	318	1	RO/CTD/ADCP	11.06.2012	03:47	BO	66° 23.96' N	28° 20.02' W		316	10	
MSM21/1b	318	1	RO/CTD/ADCP	11.06.2012	03:58	EN	66° 23.96' N	28° 20.02' W	0			
MSM21/1b	319	1	PIES	11.06.2012	09:51	BE	66° 7.23' N	27° 16.16' W	577			Hydrophone
MSM21/1b	319	1	PIES	11.06.2012	12:36	EN	66° 7.23' N	27° 16.15' W				Hydrophone on deck
MSM21/1b	320	1	RO/CTD/ADCP	11.06.2012	21:47	BE	65° 8.99' N	29° 52.21' W	1633			
MSM21/1b	320	1	RO/CTD/ADCP	11.06.2012	22:18	BO	65° 8.98' N	29° 52.22' W		1628	8	
MSM21/1b	320	1	RO/CTD/ADCP	11.06.2012	23:26	EN	65° 8.98' N	29° 52.21' W	0			
MSM21/1b	321	1	RO/CTD/ADCP	12.06.2012	00:06	BE	65° 11.98' N	29° 54.00' W	1533			Release Test.
MSM21/1b	321	1	RO/CTD/ADCP	12.06.2012	00:36	BO	65° 11.98' N	29° 54.01' W		1525	9	Release Test.
MSM21/1b	321	1	RO/CTD/ADCP	12.06.2012	01:17	EN	65° 11.98' N	29° 54.00' W				Release Test.
MSM21/1b	322	1	MB+PS	12.06.2012	01:48	BE	65° 14.43' N	29° 47.86' W	1470.8			COG 252° 8 kn SOG
MSM21/1b	322	1	MB+PS	12.06.2012	04:15	EN	65° 16.86' N	29° 50.29' W	1376.7			COG 252° 8 kn SOG
MSM21/1b	323	1	TRANS	12.06.2012	04:55	BE	65° 15.99' N	29° 59.54' W	1324.5			Transponder deployed
MSM21/1b	323	1	TRANS	12.06.2012	04:57	EN	65° 16.05' N	29° 59.53' W	1322.1			Transponder deployed
MSM21/1b	324	1	TRANS	12.06.2012	05:34	BE	65° 14.18' N	29° 58.14' W	1409.2			Transponder deployed
MSM21/1b	324	1	TRANS	12.06.2012	05:41	EN	65° 14.31' N	29° 57.87' W	1407.7			Transponder deployed
MSM21/1b	325	1	TRANS	12.06.2012	06:11	BE	65° 12.15' N	29° 56.46' W				Transponder deployed
MSM21/1b	325	1	TRANS	12.06.2012	06:16	EN	65° 12.26' N	29° 56.31' W				Transponder deployed
MSM21/1b	325	1	TRANS	12.06.2012	06:51	BE	65° 12.63' N	29° 56.35' W				Transponder/Triangul.
MSM21/1b	325	1	TRANS	12.06.2012	07:59	EN	65° 12.42' N	29° 57.57' W				Transponder/Triangul.
MSM21/1b	324	1	TRANS	12.06.2012	08:17	BE	65° 13.77' N	29° 57.71' W				Transponder/Triangul.

EXP. CODE	Stat No.	Cast No.	Type	Date dd.mm.yyyy	Time UTC	Code	Position Latitude	Longitude	Bottom depth	Max. depth	Bottom dist.	Comments
MSM21/1b	324	1	TRANS	12.06.2012	09:37	EN	65° 14.74' N	29° 56.86' W				Transponder/Triangul.
MSM21/1b	323	1	TRANS	12.06.2012	09:50	BE	65° 15.67' N	29° 58.82' W				Transponder/Triangul.
MSM21/1b	323	1	TRANS	12.06.2012	11:08	EN	65° 16.73' N	29° 59.30' W				Transponder/Triangul.
MSM21/1b	326	1	RO/CTD/ADCP	12.06.2012	12:06	BE	65° 14.99' N	29° 55.84' W	1402			Release test
MSM21/1b	326	1	RO/CTD/ADCP	12.06.2012	12:22	BO	65° 14.99' N	29° 55.84' W	1402	1390	9	Release test
MSM21/1b	326	1	RO/CTD/ADCP	12.06.2012	12:50	EN	65° 14.99' N	29° 55.84' W	1402			Release test
MSM21/1b	327	1	RO/CTD/ADCP	12.06.2012	13:16	BE	65° 18.00' N	29° 58.18' W	1260.0			
MSM21/1b	327	1	RO/CTD/ADCP	12.06.2012	13:44	BO	65° 18.00' N	29° 58.17' W		1244	10	
MSM21/1b	327	1	RO/CTD/ADCP	12.06.2012	14:43	EN	65° 18.00' N	29° 58.17' W	0.0			
MSM21/1b	328	1	VMADCP	12.06.2012	15:22	BE	65° 22.45' N	30° 6.21' W				VMADCP survey COG 154°
MSM21/1b	328	1	VMADCP	12.06.2012	16:51	EN	65° 9.28' N	29° 50.97' W				VMADCP survey COG 154°
MSM21/1b	329	1	B-ADCP	12.06.2012	18:08	BE	65° 16.93' N	30° 0.14' W	1285.5			Bottom ADCP
MSM21/1b	329	1	B-ADCP	12.06.2012	18:15	EN	65° 16.93' N	30° 0.14' W	1286.4			Bottom ADCP
MSM21/1b	330	1	B-ADCP	12.06.2012	19:12	BE	65° 11.97' N	30° 0.12' W	1485.5			Bottom ADCP
MSM21/1b	330	1	B-ADCP	12.06.2012	19:15	EN	65° 11.97' N	30° 0.12' W	1482.4			Bottom ADCP
MSM21/1b	331	1	B-ADCP	12.06.2012	19:54	BE	65° 14.51' N	29° 57.53' W	1418.9			Bottom ADCP
MSM21/1b	331	1	B-ADCP	12.06.2012	19:58	EN	65° 14.51' N	29° 57.53' W	1418.6			Bottom ADCP
MSM21/1b	332	1	B-ADCP	12.06.2012	20:36	BE	65° 14.51' N	29° 52.37' W	1456.3			Bottom ADCP
MSM21/1b	332	1	B-ADCP	12.06.2012	20:40	EN	65° 14.51' N	29° 52.37' W	1458			Bottom ADCP
MSM21/1b	333	1	AUV	12.06.2012	22:01	BE	65° 12.80' N	29° 57.99' W	1236.6			AUV in water
MSM21/1b	334	1	RO/CTD/ADCP	12.06.2012	23:52	BE	65° 14.09' N	29° 57.52' W	1418.3			w/MMS
MSM21/1b	334	1	RO/CTD/ADCP	13.06.2012	00:20	BO	65° 14.09' N	29° 57.52' W		1405	10	w/MMS
MSM21/1b	334	1	RO/CTD/ADCP	13.06.2012	01:19	EN	65° 14.14' N	29° 57.94' W				w/MMS
MSM21/1b	334	2	RO/CTD/ADCP	13.06.2012	02:10	BE	65° 14.10' N	29° 57.51' W	1418.0			w/MSS. (failed)
MSM21/1b	334	2	RO/CTD/ADCP	13.06.2012	02:38	BO	65° 14.10' N	29° 57.51' W		1408	7	w/MSS. (failed)
MSM21/1b	334	2	RO/CTD/ADCP	13.06.2012	03:24	EN	65° 14.10' N	29° 57.51' W				w/MSS. (failed)
MSM21/1b	334	3	RO/CTD/ADCP	13.06.2012	04:38	BE	65° 14.10' N	29° 57.51' W	1418.0			w/MSS

EXP. CODE	Stat No.	Cast No.	Type	Date dd.mm.yyyy	Time UTC	Code	Position Latitude	Longitude	Bottom depth	Max. depth	Bottom dist.	Comments
MSM21/1b	334	3	RO/CTD/ADCP	13.06.2012	05:07	BO	65° 14.10' N	29° 57.51' W		1407	9	w/MSS
MSM21/1b	334	3	RO/CTD/ADCP	13.06.2012	06:06	EN	65° 13.95' N	29° 58.10' W				w/MSS
MSM21/1b	334	4	RO/CTD/ADCP	13.06.2012	06:44	BE	65° 14.10' N	29° 57.51' W	1418.0			w/MSS
MSM21/1b	334	4	RO/CTD/ADCP	13.06.2012	06:44	BO	65° 14.10' N	29° 57.51' W		1407	2	w/MSS
MSM21/1b	334	4	RO/CTD/ADCP	13.06.2012	08:12	EN	65° 14.01' N	29° 58.00' W				w/MSS
MSM21/1b	334	5	RO/CTD/ADCP	13.06.2012	08:29	BE	65° 14.06' N	29° 57.74' W	1417			
MSM21/1b	334	5	RO/CTD/ADCP	13.06.2012	08:57	BO	65° 14.06' N	29° 57.74' W		1407	9	
MSM21/1b	334	5	RO/CTD/ADCP	13.06.2012	09:28	EN	65° 14.06' N	29° 57.74' W	0			
MSM21/1b	333	1	AUV	13.06.2012	11:14	EN	65° 12.37' N	29° 58.56' W				AUV on boar
MSM21/1b	335	1	MOR	13.06.2012	12:08	BE	65° 12.27' N	30° 13.02' W	1436.8			
MSM21/1b	335	1	MOR	13.06.2012	12:41	EN	65° 13.33' N	30° 13.20' W	1384.4			
MSM21/1b	336	1	MOR	13.06.2012	13:48	BE	65° 8.91' N	29° 51.01' W	1641.			
MSM21/1b	336	1	MOR	13.06.2012	14:00	EN	65° 9.30' N	29° 51.01' W	1630.			
MSM21/1b	337	1	MOR	13.06.2012	15:12	BE	65° 18.34' N	29° 37.21' W				
MSM21/1b	337	1	MOR	13.06.2012	15:23	EN	65° 18.71' N	29° 37.21' W	1366.1			
MSM21/1b	338	1	MOR	13.06.2012	16:24	BE	65° 19.70' N	29° 57.00' W	1202.3			
MSM21/1b	338	1	MOR	13.06.2012	16:38	EN	65° 20.14' N	29° 57.00' W	1185.9			
MSM21/1b	339	1	RO/CTD/ADCP	13.06.2012	18:18	BE	65° 5.36' N	29° 49.68' W	1749.7			now w/HH LADCP upward
MSM21/1b	339	1	RO/CTD/ADCP	13.06.2012	18:53	BO	65° 5.35' N	29° 49.69' W		1738	9	now w/HH LADCP upward
MSM21/1b	339	1	RO/CTD/ADCP	13.06.2012	19:27	EN	65° 5.36' N	29° 49.70' W				now w/HH LADCP upward
MSM21/1b	339	2	RO/CTD/ADCP	13.06.2012	19:54	BE	65° 5.36' N	29° 49.70' W	1750			Yoyo CTD w/MSS.
MSM21/1b	339	2	RO/CTD/ADCP	13.06.2012	20:28	BO	65° 5.36' N	29° 49.70' W		1737	9	Yoyo CTD w/MSS.
MSM21/1b	339	2	RO/CTD/ADCP	13.06.2012	21:17	EN	65° 5.30' N	29° 49.70' W				Yoyo CTD w/MSS.
MSM21/1b	339	3	RO/CTD/ADCP	13.06.2012	22:21	BE	65° 5.29' N	29° 49.78' W	1754			Yoyo CTD w/MSS.
MSM21/1b	339	3	RO/CTD/ADCP	13.06.2012	22:56	BO	65° 5.29' N	29° 49.78' W		1742	9	Yoyo CTD w/MSS.
MSM21/1b	339	3	RO/CTD/ADCP	13.06.2012	23:45	EN	65° 5.22' N	29° 49.80' W				Yoyo CTD w/MSS.
MSM21/1b	339	4	RO/CTD/ADCP	14.06.2012	00:44	BE	65° 5.36' N	29° 49.70' W	1754			w/MSS

EXP.	Stat	Cast		Date	Time		Position		Bottom	Max.	Bottom	Comments
CODE	No.	No.	Type	dd.mm.yyyy	UTC-Code		Latitude	Longitude	depth	depth	dist.	
MSM21/1b	339	4	RO/CTD/ADCP	14.06.2012	01:20	BO	65° 5.36' N	29° 49.70' W		1740	6	w/MSS
MSM21/1b	339	4	RO/CTD/ADCP	14.06.2012	02:08	EN	65° 5.36' N	29° 49.70' W				w/MSS
MSM21/1b	339	5	RO/CTD/ADCP	14.06.2012	03:32	BE	65° 5.36' N	29° 49.70' W	1754			w/MSS
MSM21/1b	339	5	RO/CTD/ADCP	14.06.2012	04:08	BO	65° 5.36' N	29° 49.70' W		1738	9	w/MSS
MSM21/1b	339	5	RO/CTD/ADCP	14.06.2012	04:54	EN	65° 5.36' N	29° 49.70' W				w/MSS
MSM21/1b	339	6	RO/CTD/ADCP	14.06.2012	05:57	BE	65° 5.36' N	29° 49.70' W				w/MSS
MSM21/1b	339	6	RO/CTD/ADCP	14.06.2012	06:30	BO	65° 5.36' N	29° 49.70' W		1738	8	w/MSS
MSM21/1b	339	6	RO/CTD/ADCP	14.06.2012	07:15	EN	65° 5.36' N	29° 49.69' W				w/MSS
MSM21/1b	340	1	MOR	14.06.2012	08:26	BE	65° 11.31' N	29° 57.52' W				
MSM21/1b	340	1	MOR	14.06.2012	09:05	EN	65° 11.80' N	30° 0.17' W	1541.8			
MSM21/1b	341	1	RO/CTD/ADCP	14.06.2012	09:51	BE	65° 12.80' N	29° 57.92' W	1466.3			w/MSS.
MSM21/1b	341	1	RO/CTD/ADCP	14.06.2012	10:20	BO	65° 12.79' N	29° 57.93' W		1450	10	w/MSS.
MSM21/1b	341	1	RO/CTD/ADCP	14.06.2012	11:02	EN	65° 12.79' N	29° 57.95' W				w/MSS.
MSM21/1b	341	2	AUV	14.06.2012	11:41	EN	65° 13.14' N	29° 57.14' W				AUV in water
MSM21/1b	342	1	MOR	14.06.2012	12:54	BE	65° 13.93' N	29° 50.72' W	1465			
MSM21/1b	342	1	MOR	14.06.2012	13:12	EN	65° 14.18' N	29° 51.71' W	1455			
MSM21/1b	343	1	MOR	14.06.2012	14:13	BE	65° 16.36' N	29° 58.50' W	1329.1			
MSM21/1b	343	1	MOR	14.06.2012	14:43	EN	65° 16.82' N	30° 0.18' W	1292.7			
MSM21/1b	344	1	RO/CTD/ADCP	14.06.2012	15:25	BE	65° 12.80' N	29° 57.94' W	1466.5			w/MSS
MSM21/1b	344	1	RO/CTD/ADCP	14.06.2012	15:57	BO	65° 12.80' N	29° 57.94' W		1449	10	w/MSS
MSM21/1b	344	1	RO/CTD/ADCP	14.06.2012	16:40	EN	65° 12.80' N	29° 57.94' W				w/MSS
MSM21/1b	344	2	RO/CTD/ADCP	14.06.2012	17:44	BE	65° 12.80' N	29° 57.99' W	1466.0			w/MSS
MSM21/1b	344	2	RO/CTD/ADCP	14.06.2012	18:13	BO	65° 12.80' N	29° 57.99' W		1449	9	w/MSS
MSM21/1b	344	2	RO/CTD/ADCP	14.06.2012	18:57	EN	65° 12.80' N	29° 57.99' W				w/MSS
MSM21/1b	344	3	RO/CTD/ADCP	14.06.2012	20:03	BE	65° 12.80' N	29° 57.99' W	1466.0			w/MSS
MSM21/1b	344	3	RO/CTD/ADCP	14.06.2012	20:32	BO	65° 12.80' N	29° 57.99' W		1451	10	w/MSS
MSM21/1b	344	3	RO/CTD/ADCP	14.06.2012	21:34	EN	65° 12.71' N	29° 58.39' W				w/MSS

EXP. CODE	Stat No.	Cast No.	Type	Date dd.mm.yyyy	Time	UTC-Code	Position Latitude	Longitude	Bottom depth	Max. depth	Bottom dist.	Comments
MSM21/1b	341	2	AUV	14.06.2012	22:22	EN	65° 14.62' N	29° 51.83' W				AUV on board
MSM21/1b	344	4	RO/CTD/ADCP	14.06.2012	22:52	BE	65° 12.80' N	29° 57.83' W	1466			w/MSS
MSM21/1b	344	4	RO/CTD/ADCP	14.06.2012	23:22	BO	65° 12.80' N	29° 57.83' W		1454	10	w/MSS
MSM21/1b	344	4	RO/CTD/ADCP	15.06.2012	00:07	EN	65° 12.80' N	29° 57.83' W				w/MSS
MSM21/1b	344	5	RO/CTD/ADCP	15.06.2012	01:41	BE	65° 12.80' N	29° 57.99' W	1466			
MSM21/1b	344	5	RO/CTD/ADCP	15.06.2012	02:09	BO	65° 12.80' N	29° 57.99' W				
MSM21/1b	344	5	RO/CTD/ADCP	15.06.2012	02:54	EN	65° 12.80' N	29° 57.99' W				Pump2 failed (upcast)
MSM21/1b	345	1	RO/CTD/ADCP	15.06.2012	08:12	BE	65° 29.97' N	31° 18.20' W	370			
MSM21/1b	345	1	RO/CTD/ADCP	15.06.2012	08:22	BO	65° 29.97' N	31° 18.20' W		357	10	
MSM21/1b	345	1	RO/CTD/ADCP	15.06.2012	08:33	EN	65° 29.97' N	31° 18.20' W	0			
MSM21/1b	346	1	RO/CTD/ADCP	15.06.2012	11:37	BE	65° 27.04' N	31° 23.63' W	647.4			
MSM21/1b	346	1	RO/CTD/ADCP	15.06.2012	11:55	BO	65° 27.04' N	31° 23.64' W		642	9	
MSM21/1b	346	1	RO/CTD/ADCP	15.06.2012	12:12	EN	65° 27.17' N	31° 24.36' W	0			
MSM21/1b	347	1	RO/CTD/ADCP	15.06.2012	13:02	BE	65° 25.03' N	31° 23.75' W	792			
MSM21/1b	347	1	RO/CTD/ADCP	15.06.2012	13:24	BO	65° 25.12' N	31° 23.99' W		762	9	
MSM21/1b	347	1	RO/CTD/ADCP	15.06.2012	13:41	EN	65° 25.24' N	31° 24.28' W	0			
MSM21/1b	348	1	RO/CTD/ADCP	15.06.2012	14:25	BE	65° 23.13' N	31° 24.21' W	912.9			
MSM21/1b	348	1	RO/CTD/ADCP	15.06.2012	14:44	BO	65° 23.20' N	31° 24.34' W		884	9	
MSM21/1b	348	1	RO/CTD/ADCP	15.06.2012	15:06	EN	65° 23.34' N	31° 24.59' W	0			
MSM21/1b	349	1	RO/CTD/ADCP	15.06.2012	15:54	BE	65° 20.96' N	31° 24.58' W	1027			
MSM21/1b	349	1	RO/CTD/ADCP	15.06.2012	16:17	BO	65° 21.09' N	31° 24.68' W		1000	9	
MSM21/1b	349	1	RO/CTD/ADCP	15.06.2012	16:39	EN	65° 21.22' N	31° 24.81' W	0			
MSM21/1b	350	1	RO/CTD/ADCP	15.06.2012	17:42	BE	65° 18.00' N	31° 24.96' W	1192.7			
MSM21/1b	350	1	RO/CTD/ADCP	15.06.2012	18:07	BO	65° 18.12' N	31° 24.92' W		1163	10	
MSM21/1b	350	1	RO/CTD/ADCP	15.06.2012	18:34	EN	65° 18.44' N	31° 25.28' W	0			
MSM21/1b	351	1	RO/CTD/ADCP	15.06.2012	19:07	BE	65° 15.03' N	31° 25.45' W	1342.5			
MSM21/1b	351	1	RO/CTD/ADCP	15.06.2012	19:35	BO	65° 15.11' N	31° 25.57' W		1319	9	

EXP. CODE	Stat No.	Cast No.	Type	Date dd.mm.yyyy	Time UTC	Code	Position Latitude	Longitude	Bottom depth	Max. depth	Bottom dist.	Comments
MSM21/1b	351	1	RO/CTD/ADCP	15.06.2012	20:03	EN	65° 15.29' N	31° 25.80' W	0			
MSM21/1b	352	1	RO/CTD/ADCP	15.06.2012	22:14	BE	65° 12.01' N	31° 25.99' W	1491.1			
MSM21/1b	352	1	RO/CTD/ADCP	15.06.2012	22:44	BO	65° 12.04' N	31° 26.11' W		1464	11	
MSM21/1b	352	1	RO/CTD/ADCP	15.06.2012	23:15	EN	65° 12.17' N	31° 26.42' W	0			
MSM21/1b	353	1	RO/CTD/ADCP	15.06.2012	23:41	BE	65° 9.02' N	31° 26.45' W	1609.3			
MSM21/1b	353	1	RO/CTD/ADCP	16.06.2012	00:11	BO	65° 9.09' N	31° 26.67' W		1590	7	
MSM21/1b	353	1	RO/CTD/ADCP	16.06.2012	00:43	EN	65° 9.22' N	31° 27.09' W				
MSM21/1b	354	1	RO/CTD/ADCP	16.06.2012	03:51	BE	65° 13.74' N	29° 58.01' W	1429.6			lADCP manual start
MSM21/1b	354	1	RO/CTD/ADCP	16.06.2012	04:20	BO	65° 13.73' N	29° 58.03' W		1415	8	
MSM21/1b	354	1	RO/CTD/ADCP	16.06.2012	04:51	EN	65° 13.73' N	29° 58.02' W				lADCP manual stop
MSM21/1b	355	1	MOR	16.06.2012	06:11	BE	65° 11.82' N	29° 54.13' W	1544.7			
MSM21/1b	355	1	MOR	16.06.2012	07:21	EN	65° 14.32' N	29° 57.49' W	1410			
MSM21/1b	356	1	AUV	16.06.2012	08:04	BE	65° 13.20' N	29° 57.51' W				AUV in Water
MSM21/1b	356	1	AUV	16.06.2012	08:41	EN	65° 13.12' N	29° 57.41' W				AUV on Board.(abort)
MSM21/1b	357	1	RO/CTD/ADCP	16.06.2012	09:05	BE	65° 13.72' N	29° 57.96' W	1428.6			w/MSS.
MSM21/1b	357	1	RO/CTD/ADCP	16.06.2012	09:33	BO	65° 13.71' N	29° 57.96' W		1415	10	w/MSS.
MSM21/1b	357	1	RO/CTD/ADCP	16.06.2012	10:18	EN	65° 13.70' N	29° 58.13' W				w/MSS.
MSM21/1b	357	2	RO/CTD/ADCP	16.06.2012	11:26	BE	65° 13.73' N	29° 57.99' W	1427			w/MSS
MSM21/1b	357	2	RO/CTD/ADCP	16.06.2012	11:53	BO	65° 13.73' N	29° 57.99' W		1418	7	w/MSS
MSM21/1b	357	2	RO/CTD/ADCP	16.06.2012	12:38	EN	65° 13.73' N	29° 58.00' W				w/MSS
MSM21/1b	358	1	AUV	16.06.2012	13:22	BE	65° 12.99' N	29° 57.42' W				AUV in Water
MSM21/1b	359	1	RO/CTD/ADCP	16.06.2012	14:26	BE	65° 13.71' N	29° 57.99' W	1428			w/MSS
MSM21/1b	359	1	RO/CTD/ADCP	16.06.2012	14:55	BO	65° 13.72' N	29° 58.01' W		1420	8	w/MSS
MSM21/1b	359	1	RO/CTD/ADCP	16.06.2012	15:39	EN	65° 13.72' N	29° 58.01' W				w/MSS
MSM21/1b	359	2	RO/CTD/ADCP	16.06.2012	16:59	BE	65° 13.74' N	29° 57.99' W	1428.7			w/MSS, aborted (MSS).
MSM21/1b	359	2	RO/CTD/ADCP	16.06.2012	17:10	BO	65° 13.74' N	29° 57.99' W				w/MSS, aborted (MSS).
MSM21/1b	359	2	RO/CTD/ADCP	16.06.2012	17:21	EN	65° 13.74' N	29° 57.99' W				w/MSS. Aborted (MSS).

EXP. CODE	Stat No.	Cast No.	Type	Date dd.mm.yyyy	Time UTC	Code	Position Latitude	Position Longitude	Bottom depth	Max. depth	Bottom dist.	Comments
MSM21/1b	359	3	RO/CTD/ADCP	16.06.2012	17:48	BE	65° 13.74' N	29° 57.99' W	1430			
MSM21/1b	359	3	RO/CTD/ADCP	16.06.2012	18:16	BO	65° 13.74' N	29° 57.99' W			9	
MSM21/1b	359	3	RO/CTD/ADCP	16.06.2012	18:48	EN	65° 13.74' N	29° 57.99' W	0			
MSM21/1b	359	4	RO/CTD/ADCP	16.06.2012	19:35	BE	65° 13.74' N	29° 57.99' W	1430.0			w/MSS.
MSM21/1b	359	4	RO/CTD/ADCP	16.06.2012	20:02	BO	65° 13.74' N	29° 57.99' W		1415	11	w/MSS.
MSM21/1b	359	4	RO/CTD/ADCP	16.06.2012	20:46	EN	65° 13.75' N	29° 58.06' W				w/MSS.
MSM21/1b	359	5	RO/CTD/ADCP	16.06.2012	23:15	BE	65° 13.74' N	29° 58.00' W	1429			w/MSS.
MSM21/1b	359	5	RO/CTD/ADCP	16.06.2012	23:44	BO	65° 13.74' N	29° 58.00' W		1415	8	w/MSS.
MSM21/1b	359	5	RO/CTD/ADCP	17.06.2012	00:38	EN	65° 13.74' N	29° 58.00' W				w/MSS. (failed)
MSM21/1b	359	6	RO/CTD/ADCP	17.06.2012	01:08	BE	65° 13.74' N	29° 57.99' W	1428.3			no lADCP
MSM21/1b	359	6	RO/CTD/ADCP	17.06.2012	01:37	BO	65° 13.74' N	29° 58.00' W		1416	8	no lADCP
MSM21/1b	359	6	RO/CTD/ADCP	17.06.2012	02:05	EN	65° 13.74' N	29° 57.99' W				no lADCP
MSM21/1b	358	1	AUV	17.06.2012	02:45	EN	65° 12.72' N	29° 58.83' W				AUV on Bord
M21/1b	360	1	RO/CTD/ADCP	17.06.2012	04:34	BE	65° 5.36' N	29° 49.71' W	1748.0			
MSM21/1b	360	1	RO/CTD/ADCP	17.06.2012	05:07	BO	65° 5.36' N	29° 49.71' W		1740	8	
MSM21/1b	360	1	RO/CTD/ADCP	17.06.2012	05:42	EN	65° 5.36' N	29° 49.71' W	0.0			
MSM21/1b	360	2	RO/CTD/ADCP	17.06.2012	06:47	BE	65° 5.36' N	29° 49.71' W	1748.0			
MSM21/1b	360	2	RO/CTD/ADCP	17.06.2012	07:22	BO	65° 5.36' N	29° 49.71' W		1740	8	
MSM21/1b	360	2	RO/CTD/ADCP	17.06.2012	07:56	EN	65° 5.36' N	29° 49.72' W	0.0			
MSM21/1b	360	3	RO/CTD/ADCP	17.06.2012	08:24	BE	65° 5.36' N	29° 49.72' W	1748.0			
MSM21/1b	360	3	RO/CTD/ADCP	17.06.2012	08:58	BO	65° 5.36' N	29° 49.72' W		1738	9	
MSM21/1b	360	3	RO/CTD/ADCP	17.06.2012	09:32	EN	65° 5.57' N	29° 50.04' W	0			
MSM21/1b	360	4	RO/CTD/ADCP	17.06.2012	10:56	BE	65° 5.36' N	29° 49.68' W	1748.0			Yoyo-CTD below 1600m
MSM21/1b	360	4	RO/CTD/ADCP	17.06.2012	11:31	BO	65° 5.36' N	29° 49.66' W		1737	9	Yoyo-CTD below 1600m
MSM21/1b	360	4	RO/CTD/ADCP	17.06.2012	15:41	EN	65° 5.36' N	29° 49.70' W				Yoyo-CTD below 1600m
MSM21/1b	361	1	RO/CTD/ADCP	17.06.2012	16:36	BE	65° 13.18' N	29° 57.09' W	1460.1			
MSM21/1b	361	1	RO/CTD/ADCP	17.06.2012	17:04	BO	65° 13.14' N	29° 57.05' W		1446	9	

EXP. CODE	Stat No.	Cast No.	Type	Date dd.mm.yyyy	Time	UTC-Code	Position Latitude	Longitude	Bottom depth	Max. depth	Bottom dist.	Comments
MSM21/1b	361	1	RO/CTD/ADCP	17.06.2012	17:36	EN	65° 13.14' N	29° 57.05' W	0			
MSM21/1b	362	1	AUV	17.06.2012	18:35	BE	65° 13.56' N	29° 55.22' W				AUV in water
MSM21/1b	363	1	RO/CTD/ADCP	17.06.2012	19:22	BE	65° 13.74' N	29° 57.98' W	1428.5			w/MSS
MSM21/1b	363	1	RO/CTD/ADCP	17.06.2012	19:50	BO	65° 13.74' N	29° 57.99' W		1413	9	w/MSS
MSM21/1b	363	1	RO/CTD/ADCP	17.06.2012	20:36	EN	65° 13.74' N	29° 57.98' W				w/MSS
MSM21/1b	363	2	RO/CTD/ADCP	17.06.2012	21:50	BE	65° 13.75' N	29° 57.96' W	1428			w/MSS.
MSM21/1b	363	2	RO/CTD/ADCP	17.06.2012	22:18	BO	65° 13.75' N	29° 57.96' W		1413	9	w/MSS.
MSM21/1b	363	2	RO/CTD/ADCP	17.06.2012	23:04	EN	65° 13.72' N	29° 57.90' W				w/MSS.
MSM21/1b	363	3	RO/CTD/ADCP	18.06.2012	00:36	BE	65° 13.75' N	29° 57.95' W	1427			w/MSS
MSM21/1b	363	3	RO/CTD/ADCP	18.06.2012	01:06	BO	65° 13.75' N	29° 57.95' W		1415	8	w/MSS
MSM21/1b	363	3	RO/CTD/ADCP	18.06.2012	01:47	EN	65° 13.75' N	29° 57.95' W				w/MSS
MSM21/1b	363	4	RO/CTD/ADCP	18.06.2012	02:58	BE	65° 13.75' N	29° 57.96' W	1427			w/MSS. (failed)
MSM21/1b	363	4	RO/CTD/ADCP	18.06.2012	03:27	BO	65° 13.75' N	29° 57.96' W		1416	8	w/MSS. (failed)
MSM21/1b	363	4	RO/CTD/ADCP	18.06.2012	04:12	EN	65° 13.75' N	29° 57.96' W				w/MSS. (failed)
MSM21/1b	363	5	RO/CTD/ADCP	18.06.2012	05:31	BE	65° 13.74' N	29° 57.99' W	1427			w/MSS
MSM21/1b	363	5	RO/CTD/ADCP	18.06.2012	06:00	BO	65° 13.74' N	29° 57.99' W		1416	8	w/MSS
MSM21/1b	363	5	RO/CTD/ADCP	18.06.2012	06:41	EN	65° 13.74' N	29° 57.99' W				w/MSS
MSM21/1b	362	1	AUV	18.06.2012	08:26	EN	65° 14.22' N	29° 54.58' W				AUV on board
MSM21/1b	364	1	RO/CTD/ADCP	18.06.2012	10:51	BE	65° 42.00' N	29° 52.20' W	320			
MSM21/1b	364	1	RO/CTD/ADCP	18.06.2012	11:03	BO	65° 41.99' N	29° 52.22' W		300	9	
MSM21/1b	364	1	RO/CTD/ADCP	18.06.2012	11:16	EN	65° 41.99' N	29° 52.23' W	0			
MSM21/1b	365	1	RO/CTD/ADCP	18.06.2012	11:49	BE	65° 38.98' N	29° 51.98' W	300.3			
MSM21/1b	365	1	RO/CTD/ADCP	18.06.2012	11:59	BO	65° 38.98' N	29° 51.99' W		296	8	
MSM21/1b	365	1	RO/CTD/ADCP	18.06.2012	12:08	EN	65° 38.98' N	29° 51.99' W	0			
MSM21/1b	366	1	RO/CTD/ADCP	18.06.2012	12:40	BE	65° 36.02' N	29° 51.68' W	323			
MSM21/1b	366	1	RO/CTD/ADCP	18.06.2012	12:50	BO	65° 36.02' N	29° 51.67' W		311	8	
MSM21/1b	366	1	RO/CTD/ADCP	18.06.2012	12:59	EN	65° 36.02' N	29° 51.67' W	0			

EXP. CODE	Stat No.	Cast No.	Type	Date dd.mm.yyyy	Time	UTC-Code	Position Latitude	Longitude	Bottom depth	Max. depth	Bottom dist.	Comments
MSM21/1b	367	1	RO/CTD/ADCP	18.06.2012	13:35	BE	65° 33.01' N	29° 51.57' W	360			
MSM21/1b	367	1	RO/CTD/ADCP	18.06.2012	13:44	BO	65° 33.01' N	29° 51.57' W		350	8	
MSM21/1b	367	1	RO/CTD/ADCP	18.06.2012	13:53	EN	65° 33.01' N	29° 51.57' W	0			
MSM21/1b	368	1	RO/CTD/ADCP	18.06.2012	14:27	BE	65° 30.03' N	29° 51.39' W	521			
MSM21/1b	368	1	RO/CTD/ADCP	18.06.2012	14:40	BO	65° 30.03' N	29° 51.39' W		510	8	
MSM21/1b	368	1	RO/CTD/ADCP	18.06.2012	14:52	EN	65° 30.03' N	29° 51.39' W	0			
MSM21/1b	369	1	RO/CTD/ADCP	18.06.2012	15:21	BE	65° 27.01' N	29° 51.17' W	780			
MSM21/1b	369	1	RO/CTD/ADCP	18.06.2012	15:38	BO	65° 27.01' N	29° 51.17' W		767	8	
MSM21/1b	369	1	RO/CTD/ADCP	18.06.2012	15:55	EN	65° 26.99' N	29° 51.44' W	0			
MSM21/1b	370	1	RO/CTD/ADCP	18.06.2012	16:42	BE	65° 24.00' N	29° 50.96' W	1005.4			w/MSS
MSM21/1b	370	1	RO/CTD/ADCP	18.06.2012	17:04	BO	65° 24.00' N	29° 51.05' W		990	9	w/MSS
MSM21/1b	370	1	RO/CTD/ADCP	18.06.2012	17:27	EN	65° 24.03' N	29° 51.31' W				w/MSS
MSM21/1b	371	1	RO/CTD/ADCP	18.06.2012	17:58	BE	65° 21.00' N	29° 50.71' W	1194			
MSM21/1b	371	1	RO/CTD/ADCP	18.06.2012	18:23	BO	65° 21.00' N	29° 50.70' W			9	
MSM21/1b	371	1	RO/CTD/ADCP	18.06.2012	18:49	EN	65° 21.05' N	29° 50.85' W	0			
MSM21/1b	372	1	RO/CTD/ADCP	18.06.2012	19:16	BE	65° 18.01' N	29° 50.54' W	1335.1			
MSM21/1b	372	1	RO/CTD/ADCP	18.06.2012	19:42	BO	65° 18.02' N	29° 50.62' W		1322	9	
MSM21/1b	372	1	RO/CTD/ADCP	18.06.2012	20:12	EN	65° 18.05' N	29° 50.85' W	0			
MSM21/1b	373	1	RO/CTD/ADCP	18.06.2012	20:54	BE	65° 11.99' N	29° 50.07' W	1548.1			
MSM21/1b	373	1	RO/CTD/ADCP	18.06.2012	21:23	BO	65° 11.99' N	29° 50.07' W		1534	9	
MSM21/1b	373	1	RO/CTD/ADCP	18.06.2012	21:54	EN	65° 11.99' N	29° 50.07' W	0			
MSM21/1b	374	1	AUV	18.06.2012	22:46	BE	65° 14.14' N	29° 55.22' W				AUV in water
MSM21/1b	375	1	RO/CTD/ADCP	18.06.2012	23:41	BE	65° 13.77' N	29° 57.95' W	1426.9			w/MSS
MSM21/1b	375	1	RO/CTD/ADCP	18.06.2012	23:43	BO	65° 13.77' N	29° 57.95' W		1414	8	w/MSS
MSM21/1b	375	1	RO/CTD/ADCP	19.06.2012	00:52	EN	65° 13.77' N	29° 57.95' W				w/MSS
MSM21/1b	375	2	RO/CTD/ADCP	19.06.2012	02:14	BE	65° 13.74' N	29° 57.99' W	1426.6			Yoyo-CTD below 1000m
MSM21/1b	375	2	RO/CTD/ADCP	19.06.2012	02:43	BO	65° 13.74' N	29° 57.99' W		1414	8	Yoyo-CTD below 1000m

EXP. CODE	Stat No.	Cast No.	Type	Date dd.mm.yyyy	Time	UTC-Code	Position Latitude	Longitude	Bottom depth	Max. depth	Bottom dist.	Comments
MSM21/1b	375	2	RO/CTD/ADCP	19.06.2012	04:00	EN	65° 13.74' N	29° 57.99' W				Yoyo-CTD below 1000m
MSM21/1b	375	3	RO/CTD/ADCP	19.06.2012	04:27	BE	65° 13.74' N	29° 57.99' W	1426			Yoyo-CTD below 1000m
MSM21/1b	375	3	RO/CTD/ADCP	19.06.2012	04:55	BO	65° 13.74' N	29° 57.99' W				Yoyo-CTD below 1000m
MSM21/1b	375	3	RO/CTD/ADCP	19.06.2012	06:59	EN	65° 13.74' N	29° 57.99' W				Yoyo-CTD below 1000m
MSM21/1b	375	4	RO/CTD/ADCP	19.06.2012	07:25	BE	65° 13.74' N	29° 57.99' W	1424			w/MSS
MSM21/1b	375	4	RO/CTD/ADCP	19.06.2012	07:53	BO	65° 13.74' N	29° 57.99' W		1415	9	w/MSS
MSM21/1b	375	4	RO/CTD/ADCP	19.06.2012	08:36	EN	65° 13.74' N	29° 57.99' W				w/MSS
MSM21/1b	375	5	RO/CTD/ADCP	19.06.2012	09:11	BE	65° 13.74' N	29° 57.94' W	1424			
MSM21/1b	375	5	RO/CTD/ADCP	19.06.2012	09:38	BO	65° 13.74' N	29° 57.93' W		1414	9	
MSM21/1b	375	5	RO/CTD/ADCP	19.06.2012	10:07	EN	65° 13.74' N	29° 57.93' W	0			
MSM21/1b	375	6	RO/CTD/ADCP	19.06.2012	10:49	BE	65° 13.74' N	29° 57.94' W	1424			
MSM21/1b	375	6	RO/CTD/ADCP	19.06.2012	11:17	BO	65° 13.74' N	29° 57.93' W		1413	10	
MSM21/1b	375	6	RO/CTD/ADCP	19.06.2012	11:46	EN	65° 13.74' N	29° 57.94' W	0			
MSM21/1b	374	1	AUV	19.06.2012	13:17	EN	65° 14.70' N	29° 59.00' W				AUV on board
MSM21/1b	323	1	TRANS	19.06.2012	14:12	EN	65° 16.14' N	30° 0.35' W				Transponder picked up
MSM21/1b	376	1	RO/CTD/ADCP	19.06.2012	14:37	BE	65° 13.73' N	29° 57.94' W	1427			Yoyo-CTD below 1000m
MSM21/1b	376	1	RO/CTD/ADCP	19.06.2012	15:08	BO	65° 13.73' N	29° 57.94' W		1418	9	Yoyo-CTD below 1000m
MSM21/1b	376	1	RO/CTD/ADCP	19.06.2012	18:23	EN	65° 13.73' N	29° 57.95' W				Yoyo-CTD below 1000m
MSM21/1b	376	2	RO/CTD/ADCP	19.06.2012	19:05	BE	65° 13.73' N	29° 57.95' W	1427			w/MSS
MSM21/1b	376	2	RO/CTD/ADCP	19.06.2012	19:33	BO	65° 13.73' N	29° 57.95' W		1417	9	w/MSS
MSM21/1b	376	2	RO/CTD/ADCP	19.06.2012	20:18	EN	65° 13.74' N	29° 57.93' W				w/MSS
MSM21/1b	376	3	RO/CTD/ADCP	19.06.2012	21:23	BE	65° 13.75' N	29° 58.00' W	1427			w/MSS
MSM21/1b	376	3	RO/CTD/ADCP	19.06.2012	21:51	BO	65° 13.74' N	29° 58.00' W		1417	9	w/MSS
MSM21/1b	376	3	RO/CTD/ADCP	19.06.2012	22:36	EN	65° 13.79' N	29° 57.89' W				w/MSS
MSM21/1b	376	4	RO/CTD/ADCP	19.06.2012	23:46	BE	65° 13.75' N	29° 58.00' W	1427			w/MSS
MSM21/1b	376	4	RO/CTD/ADCP	20.06.2012	00:13	BO	65° 13.75' N	29° 57.99' W		1420	6	w/MSS
MSM21/1b	376	4	RO/CTD/ADCP	20.06.2012	00:55	EN	65° 13.75' N	29° 57.99' W				w/MSS

EXP. CODE	Stat No.	Cast No.	Type	Date dd.mm.yyyy	Time UTC	Code	Position Latitude	Longitude	Bottom depth	Max. depth	Bottom dist.	Comments
MSM21/1b	376	5	RO/CTD/ADCP	20.06.2012	02:06	BE	65° 13.75' N	29° 57.99' W	1427			
MSM21/1b	376	5	RO/CTD/ADCP	20.06.2012	02:35	BO	65° 13.75' N	29° 57.99' W		1421	7	
MSM21/1b	376	5	RO/CTD/ADCP	20.06.2012	03:16	EN	65° 13.75' N	29° 57.99' W	0			
MSM21/1b	377	1	AUV	20.06.2012	06:06	BE	65° 13.04' N	29° 58.35' W				AUV in water (abort)
MSM21/1b	377	1	AUV	20.06.2012	07:51	EN	65° 12.82' N	29° 58.51' W				AUV on board
MSM21/1b	377	2	RO/CTD/ADCP	20.06.2012	08:12	BE	65° 12.98' N	29° 58.07' W	1460			
MSM21/1b	377	2	RO/CTD/ADCP	20.06.2012	08:42	BO	65° 12.97' N	29° 58.08' W		1446	9	
MSM21/1b	377	2	RO/CTD/ADCP	20.06.2012	09:12	EN	65° 12.97' N	29° 58.08' W				
MSM21/1b	377	3	AUV	20.06.2012	09:18	BE	65° 12.97' N	29° 58.08' W				AUV in water
MSM21/1b	378	1	RO/CTD/ADCP	20.06.2012	10:52	BE	65° 14.67' N	29° 49.81' W	1453.5			
MSM21/1b	378	1	RO/CTD/ADCP	20.06.2012	11:20	BO	65° 14.67' N	29° 49.81' W		1440	9	
MSM21/1b	378	1	RO/CTD/ADCP	20.06.2012	11:48	EN	65° 14.67' N	29° 49.81' W	0			
MSM21/1b	379	1	RO/CTD/ADCP	20.06.2012	12:17	BE	65° 16.08' N	29° 42.94' W	1463			
MSM21/1b	379	1	RO/CTD/ADCP	20.06.2012	12:46	BO	65° 16.08' N	29° 42.93' W		1449	8	
MSM21/1b	379	1	RO/CTD/ADCP	20.06.2012	13:13	EN	65° 16.08' N	29° 42.92' W	0			
MSM21/1b	380	1	RO/CTD/ADCP	20.06.2012	13:41	BE	65° 17.41' N	29° 35.95' W	1435			
MSM21/1b	380	1	RO/CTD/ADCP	20.06.2012	14:11	BO	65° 17.41' N	29° 35.95' W		1425	7	
MSM21/1b	380	1	RO/CTD/ADCP	20.06.2012	14:40	EN	65° 17.41' N	29° 35.95' W	0			
MSM21/1b	377	3	AUV	20.06.2012	16:08	EN	65° 17.40' N	29° 38.18' W				AUV on board
MSM21/1b	325	1	TRANS	20.06.2012	18:02	EN	65° 14.70' N	29° 58.68' W				Transponder picked up
MSM21/1b	324	1	TRANS	20.06.2012	19:00	EN	65° 12.56' N	29° 56.93' W				Transponder picked up
MSM21/1b	381	1	RO/CTD/ADCP	20.06.2012	23:10	BE	64° 28.73' N	30° 51.57' W	2472.7			for EM120 calibration
MSM21/1b	381	1	RO/CTD/ADCP	20.06.2012	23:41	BO	64° 28.73' N	30° 51.57' W		1900		for EM120 calibration
MSM21/1b	381	1	RO/CTD/ADCP	21.06.2012	00:08	EN	64° 28.73' N	30° 51.57' W				for EM120 calibration
MSM21/1b	381	2	EM120	21.06.2012	00:16	BE	64° 28.20' N	30° 51.50' W	2479			EM120 calibration
MSM21/1b	381	2	EM120	21.06.2012	07:30	EN	64° 28.18' N	30° 51.50' W				EM120 calibration
MSM21/1b	382	1	RO/CTD/ADCP	21.06.2012	10:02	BE	64° 13.19' N	29° 56.72' W	2425.5			for EM120 calibration

EXP. CODE	Stat No.	Cast No.	Type	Date dd.mm.yyyy	Time UTC	Code	Position Latitude	Longitude	Bottom depth	Max. depth	Bottom dist.	Comments
MSM21/1b	382	1	RO/CTD/ADCP	21.06.2012	10:32	BO	64° 13.18' N	29° 56.70' W		1901		for EM120 calibration
MSM21/1b	382	1	RO/CTD/ADCP	21.06.2012	11:09	EN	64° 13.18' N	29° 56.70' W				for EM120 calibration
MSM21/1b	382	2	EM120	21.06.2012	11:20	BE	64° 13.33' N	29° 55.94' W				EM120 calibration
MSM21/1b	382	2	EM120	21.06.2012	15:12	EN	64° 16.45' N	29° 40.26' W				EM120 calibration

8 Data and Sample Storage and Availability

The Kiel Data Management Team (KDMT) provides an information and data archival system where metadata of the onboard DSHIP-System is collected and publicly available. This Ocean Science Information System (OSIS-Kiel) is accessible for all project participants and can be used to share and edit field information and to provide scientific data, as they become available. The central system OSIS is providing information on granted ship time with information on the scientific program and the general details down to the availability of data files from already concluded cruises. The transparency on the research activities is regarded as an invitation to external scientists to start communication on collaboration on behalf of the newly available data.

The KDMT will take care as data curators to fulfill the here proposed data publication of the data in a World Data Center (e.g. PANGAEA) which will then provide long-term archival and access to the data. The data publication process will be based on the available files in OSIS and is therefore transparent to all reviewers and scientists. This cooperation with a world data center will make the data globally searchable, and links to the data owners will provide points of contact to project-external scientists.

Availability of metadata in OSIS-Kiel (portal.geomar.de/osis): 2 weeks after the cruise.

Availability of data in OSIS-Kiel (portal.geomar.de/osis): 6 months after the cruise.

Availability of data in a WDC/PANGAEA (www.pangaea.de): 3 years after the cruise.

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vessel-mounted 38 KHz ADCP aboard R/V MARIA S. MERIAN. A special thanks goes to the tremendously calm seas throughout the cruise that everyone on board enjoyed.

10 References

Brearley, J. A., Pickart, R. S., Valdimarsson, H., Jonsson, S., Schmitt, R. W. and Haine, T. (2012): The East Greenland Boundary Current System South of Denmark Strait. *Deep Sea Research I*, 63, 1-19, doi:10.1016/j.dsr.2012.01.001

Dickson, R.R., Brown, J. (1994): The production of North Atlantic deep water: sources, rates, and pathways. *J. Geophys. Res.* 99, 12319–12341.

Girton, J. B. (2001):Dynamics of transport and variability in the Denmark Strait overflow. Ph.D. thesis, University of Washington, Seattle, WA.

Goodman, L., Levine, E.R., Lueck, R.G. (2006): On measuring the terms of the turbulent kinetic energy budget from an AUV. *J. Atmos. Ocean. Technol*. 23, 977–990.

Jonsson, S. and Valdimarsson, H. (2004): A new path for the Denmark Strait overflow water from the Iceland Sea to Denmark Strait. *Geophys. Res. Let. 31: doi: 10.1029/2003GL019214. issn: 0094-8276.*

Käse, R.H. (2006): A Riccati model for Denmark Strait overflow variability. Geophys. Res. Let., 33, L21S09, doi:10.1029/2006GRL026915.

Macrander, A., U. Send, H. Valdimarsson, S. Jónsson, and R.H. Käse (2005): Interannual changes in the overflow core from the Nordic seas into the Atlantic Ocean through Denmark Strait. Geophys. Res. Lett., 32, L06606.

Pickart, R.S., Torres, D.J., Fratantoni, P.S. (2005) The East Greenland spill jet. *J. Phys. Oceanogr.* 35, 1037–1053.

Voet, G. (2006): Entrainment in the Denmark Strait Overflow Plume by meso-scale Eddies. Diploma Thesis, University of Hamburg, 89 pp.

Voet G. and D. Quadfasel (2010): Entrainment in the Denmark Strait overflow plume by meso-scale eddies, *Ocean Sci. Discuss.*: 301-310.

Appendices

Appendix A Diary of MSM 21-1b (09 June – 22 June)

Saturday, 09 June 2012 (Test and Transit)

08:00 Departure from Reykjavik (calm conditions)

10:00 AUV Test. Position alignment of AUV did not work on deck. AUV was launched on the sea surface. Still no success. After a reset the alignment worked and AUV accomplished a test dive in 50 m water depth for one hour. Microstructure sensor recorded data.
Test CTD carried out at the same site. CTD worked fine (T sensor problem from previous cruise a visible any more). LADCP (we used the Hamburg double LADCP pack) showed that the up-looking device had severe problem (software said that beams 1, 2, & 3 were broken).
The 38 Khz ADCP with the beamformer board from FS Meteor installed seems to work smoothly.

Sunday, 10 June 2012 (Denmark Strait; 5 Beaufort)

03:00 PIES Telemetry DS1-11 using 200 m transducer cable. We kept position above PIES during the operation (no drifting). After initial problems (documentation from Bremen regarding the channel frequencies was wrong) the entire data set was retrieved.

08:00 Beginn of CTD section (#95) across Denmark Strait stating on the southern end
CTD Section with 3 nm spacing. It is amazing to see how sharp the temperature front between the Irminger Sea water and the East Greenland current is. Because of ice situation the 3 northern-most sections could not be reached, yet the overflow itself was well-covered. Test with Vadim MSS probe failed. Probe half-detached from frame at sea surface. Its release was then not properly coordinated with the bridge, which lead to some discussion. Finally the probe was recovered successfully.

18:00 Recovery of ADCP in central Denmark Strait (no problems)
Cook offers to cook food chosen by science party

Monday, 11 June 2012 (From Denmark Strait to entrainment area; calm seas)

04:00 End of CTD section (#111) across Denmark Strait at (66° 23.96’N / 28° 20.01’W). Last three stations were skipped on the Greeland due to sea ice conditions.

10:00 Upload of data from second PIES in Denmark Strait (DS2-11). Upload was successful, yet the data (espectially the pressure channel) is quite gappy.
Transit to entrainment area.

22:00 Two CTD casts (#113-114) for Releases and Microcats accomplished in entrainment area.

Tuesday, 12 June 2012 (Entrainment area; calm seas)

02:00 Topographic survey in for AUV deployment in center part of planned entrainment mooring array (near 1400 m depth). Done with 8 kn speed. Continental slope turns out to be rather smooth.

05:00 3 x transponder deployment (for AUV navigation) and subsequent triangulation. First transponder dropped 2 cables off desired location due to miscommunication between bridge and deck. Triangulation took significantly longer than estimated.

11:30 Two CTD (#115-116) in the central entrainment area (release test, MC calibration)

15:30 Cross-slope LADCP survey in the entrainment area to assess overflow strength.

18:00 Deployment of the 4 centre ADCP moorings (ADCP1-4)

22:00 AUV launch (#02) in central entrainment area.

Wednesday, 13 June 2012 (Entrainment area; calm seas)

00:00 Four CTDs (#117-121) with Baklan MSS profiler in central array area

11:00 Recovery of AUV (#02). Successful mission

12:00 Deployment of the 4 outer RCM moorings (RCM #1-4)

18:00 6 CTD Stations (#122-127) in southern (offshore) entrainment area (1754 m water depth) overflow plum is very thin (~30 m).

Thursday, 14 June 2012 (Entrainment area; calm seas)

08:30 Deployment of MicroCAT mooring in central array

10:00 CTD (#128) in central array area with Baklan MSS

12:30 AUV (#03) launch.

13:00 Employment of 2 MicroCAT moorings in central array

14:00 CTDs (#129-131) in central array area with Baklan MSS

22:00 Emergency recovery of AUV (#03). AUV did not reach first way point (going against the overflow) due to strong flow. AUV had already been long at the surface before message was received is satellite communication.

22:30 CTDs (#132-133) in central array area (#132 with Baklan MSS)

Friday, 15 June 2012 (Spilljet section; calm seas; sea ice)

00:00 Transit to Spilljet section
Upon arrival at Spilljet section starting on shelf of Greenland we experience slow progress due to the presence of sea ice.

9:00 3 x zodiac trips for science party through the ice covered seas

12:00 CTDs (#132 – 142) along spilljet section

Saturday, 16 June 2012 (Entrainment area; calm seas)

04:00 CTD (#143) in central array area

06:00 Deployment of Aquadopp mooring in central part of array

08:00 Lauch of AUV (#04). Mission stopped due to leakage warning at 100 m depth

09:00 CTD (#144 - 145) in central array area (with Baklan MSS)

13:30 Launch of AUV (#05)

14:00 CTD (#146 - 150) in central array area (partly with Baklan MSS; technical problems)

Sunday, 17 June 2012 (Entrainment area; calm seas)

02:00 Recovery of AUV (#05). Successful mission

04:30 CTD (#151-153) in southern array area (without Baklan MSS)

11:00 Yo-yo CTD (#154) in southern array area btw. 1600 m and bottom (1754m)

16:30 CTD (#155) in central array area (without Baklan MSS)

18:30 Launch of AUV (#06)

19:30 CTD (#156-160) at central array position

Monday, 18 June 2012 (Entrainment area; calm seas)

8:00 AUV (#06) recovery; successful mission

11:00 CTD Section downslope through central array area. No sea ice on shelf edge.

23:00 AUV (#07) deployment

Tuesday, 19 June 2012 (Entrainment area; 5-6 Beaufort)

00:00 CTDs (#171 – 176) in central array area (#172 & 173 were done so yo-yos; #171 & 174 with Baklan MSS)

13:00 AUV (#07) recovery; successful mission

14:00 Recovery of northern transponder

14:30 CTD (#177-181) at central array station. #177 done as yo-yo; #178, 178, 180 with Baklan MSS

Wednesday, 20 June 2012 (Entrainment area; Transit to swath echosounder survey)

06:00 AUV(#08) Deployment; did not reach first way point, emergency recovery

08:00 CTD #182

09:30 AUV (#09) Deployment. Long mission against flow at 100 m above bottom out of reach of transponder navigation.

11:00 CTD (#183-185) along AUV track

16:00 AUV (#09) recovery; successful mission

17:50 Recovery of two transponders

23:00 Echosounder calibration site I including CTD #186

Thursday, 21 June 2012 (Swath echosounder survey)

10:00 Echosounder calibration site II including CTD #187

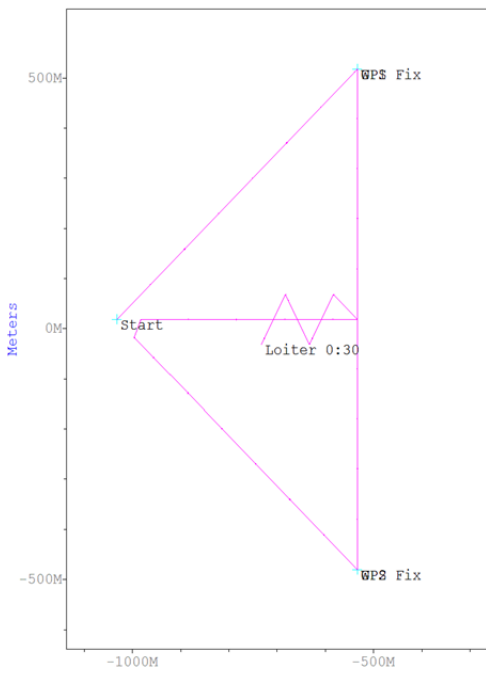
******End of Science ******

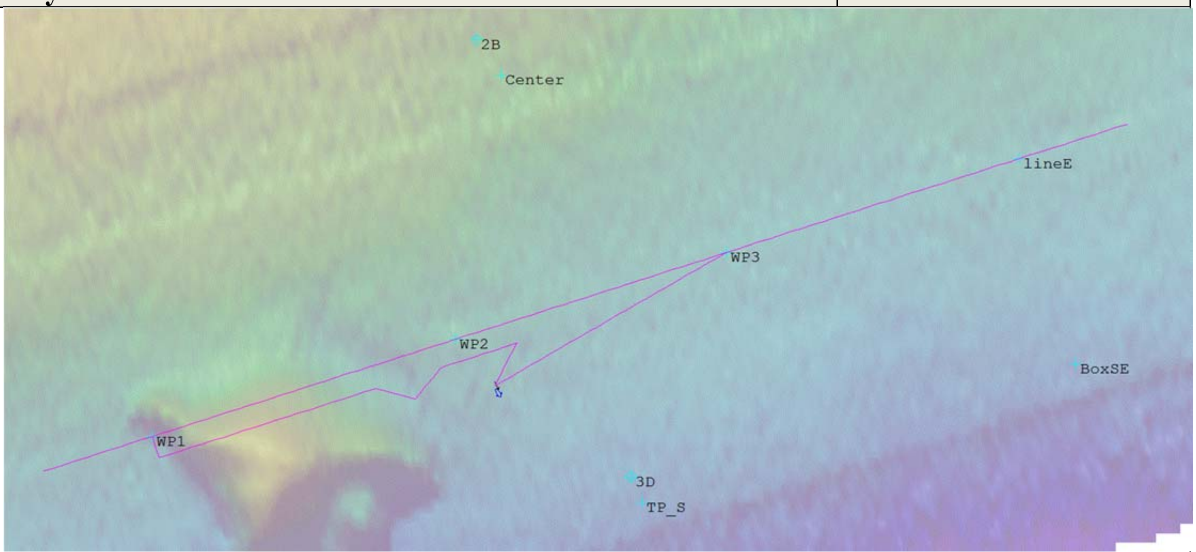
Friday, 22 June 2012

Arrival in Reykjavik

Appendix B AUV mission summary

All of the missions or at least the survey phases above the seafloor had a fix propeller revolution of 225 rpm what is equivalent to 3 knots. Each for the survey relevant leg was proceeded in depth mode to achieve a smooth running AUV with less pitch.

Abyss0090 - Test Dive - 1st AUV-Dive MSM21-1b	09.06.2012
	The test dive replaced the usual harbor test that could not be done due to the LARS position on the starboard side. Purposes: - check vehicle health - verify functions of the Multibeam Echo sounder - verify function of the Microstructure probe - log vehicle behaviour that can be used as reference for the Microstructure probe

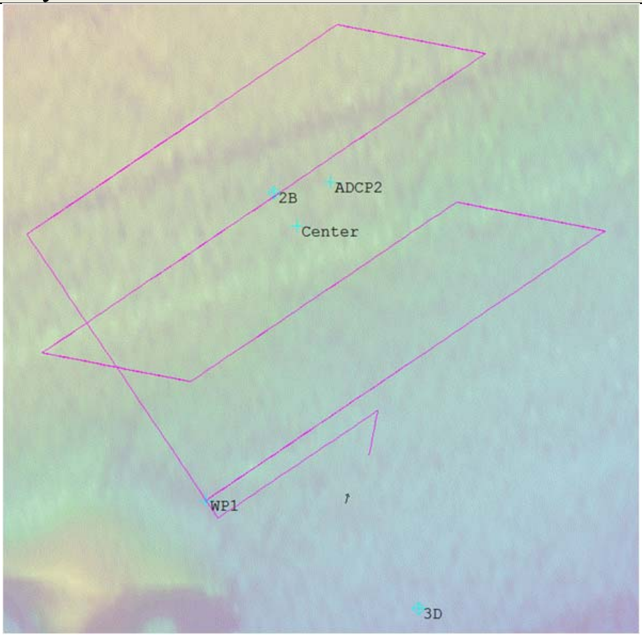
Abyss0091 – 2nd AUV-Dive MSM21-1b	12.06.2012
	
Dive 91 proceeded in 6 depth steps on top of each other to find the coldwater overflow close to the sea floor (depth steps: 1415, 1365, 1315, 1265, 1215, 1165 meters). The first step was supposed to start at an altitude of ca. 50 meters at a constant depth of 1415 meters. - fixed propeller revolutions (225 rpm) to get an equal speed through the water (microstructure probe)	

- Reson Multibeam echosounder logged on depth of 1315 meters (Range: 375m / 200 kHz)
- mission aborted on the last depth step due to battery capacity less than 5%
- insufficient LBL position fixes on the outer legs of the straight tracks (ends too far away from the LBL baseline)
- defect cable of a proximity sensor caused a ground fault

Abyss0092 – 3rd AUV-Dive MSM21-1b	14.06.2012
	Dive 92 was already aborted on the first leg to northeast because a timeout. The vehicle could not reach the end of the leg because of strong counter currents which reduced the vehicle speed up to less than one knots. The timeout for this leg was set to 80 minutes.

Abyss0093 – 4th AUV-Dive MSM21-1b	16.06.2012
	Dive 93 was aborted due to a leak message from the vehicle tail section just as the vehicle started the drive descent mode. The leak sensor inside the oily section of the tail responded because of a water drop inside the oil.

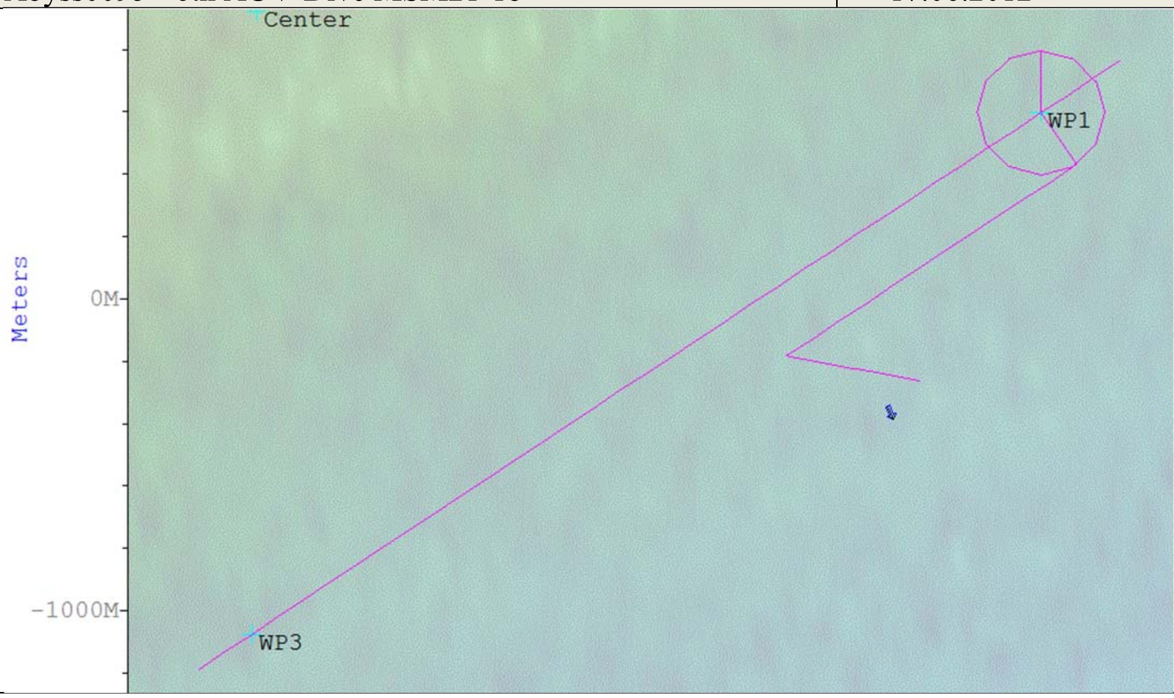
Abyss0094 - 5th AUV-Dive MSM21-1b	16.06.2012



Dive 94 was subdivided in four parallel tracks each orientated on the contour lines following the slope. Each track was on a constant depth to get a smooth moving vehicle. The altitude was supposed to be either 100 or 200 meters. The higher altitude was chosen on countercurrent tracks (northeast course). The overflow was weaker above 150 meters.

Some settings were change for this and the subsequent missions to achieve a smooth running vehicle. The AUV must not follow the track line exactly to avoid heading across the current. Each track is also divided in half while maintaining the timeout time. The vehicle was as well enabled to accept LBL positions permanently to avoid bigger position corrections.

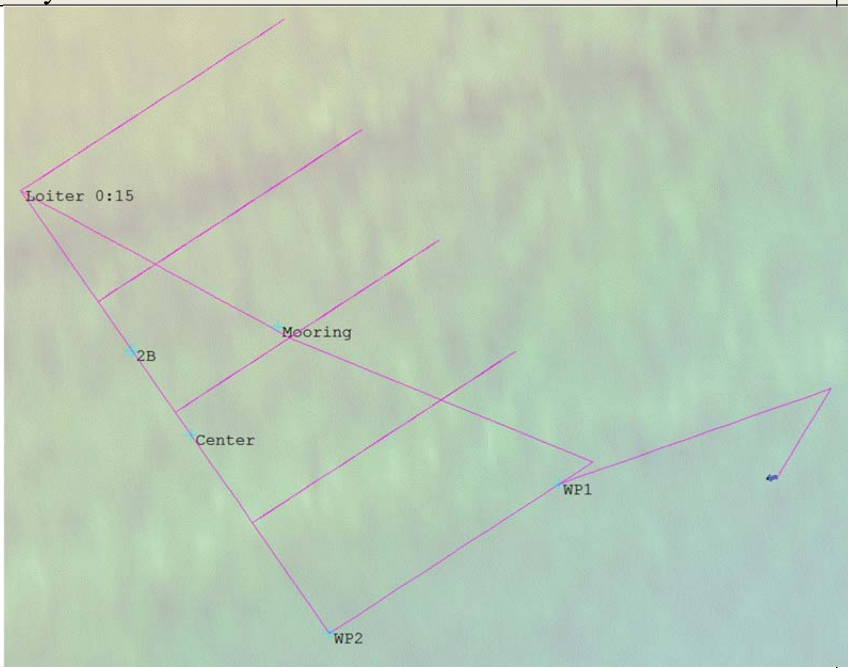
Abyss0095 - 6th AUV-Dive MSM21-1b	17.06.2012



Dive 95 happened again above the 1450 meters contour line. Between two waypoints the vehicle proceeded on 1250 meters depths against the current and on definite depths between

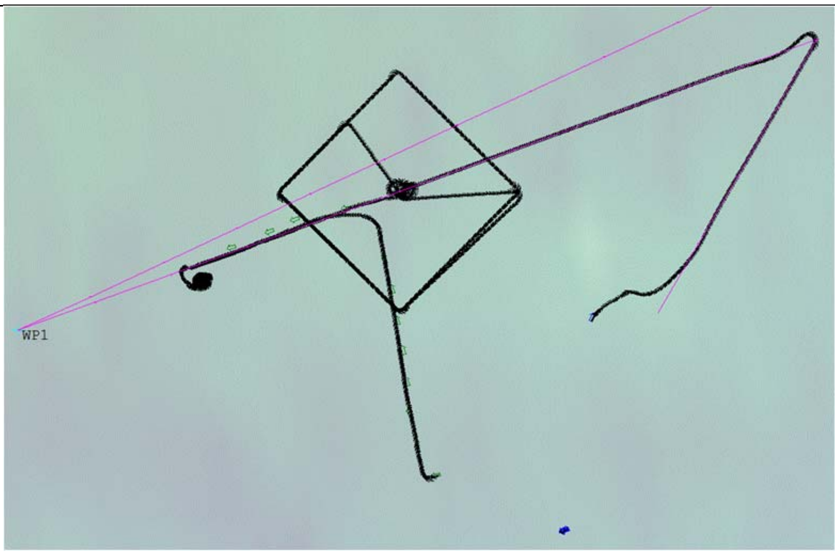
1300 and 1400 meters with the current. The circle at the end of the mission was to record data with the microstructure probe in different orientations.

The mission Abyss 0095 was successful but just before the vehicle was pulled on board the ascent weight got lost due to a leak in the dry tail section.

<table>
<tr><th>Abyss0096 - 7th AUV-Dive MSM21-1b</th><th>19.06.2012</th></tr>
<tr><td>
</td><td>The mission plan of dive 96 consisted of 5 tracks app. 100 meters above the seafloor. Each track was orientated on the contour lines. The counter current tracks on the way back proceeded at app. 200 meters altitude to avoid the water flow close to the seabed. At the end of a 5 track group the vehicle went to the beginning down slope at a specified altitude of 50 meters. The vehicle logged low frequency (120 kHz/Range: 500 m) sidescan data while it runs on diagonal tracks.

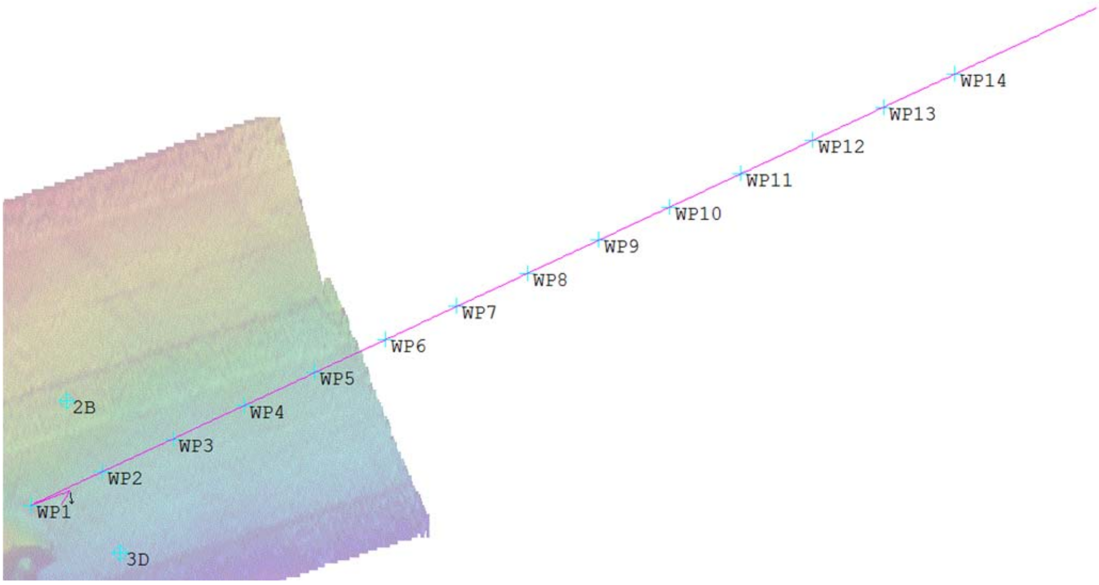
The last leg was a so called loiter phase. A leak in both the oily and the dry section of the tail caused an abort while this leg. The tail section was replaced after dive 96.</td></tr>
</table>

Abyss0097 - 8th AUV-Dive MSM21-1b	20.06.2012



Dive 97 was aborted before the vehicle arrived at the northwest track. Other than before the current came from southwest and the vehicle couldn't catch the next waypoint.

Abyss0098 - 9th AUV-Dive MSM21-1b	20.06.2012



During mission 98 it was intended to measure a long transect above one specific contour line and on one depth to achieve a smooth running vehicle on a consistently altitude. The ship proceeded CTD stations while the vehicle was running. The vehicle speed decreased continuously during this mission what probably was caused by an increasing current. Between waypoint 9 and 10 the vehicle got a redirect command from the ship based station to reach the surface without losing the ascent weight.

Appendix C MSM 21 1b LADCP Protokol

The second leg og MSM 21 1 started at profile 94
Sensors used: SN 680 as upward looking LADCP and SN 6468 as downward looking LADCP.
Battery case SN 003.
Given below are starting times of the casts
Profile 94 am 09.06.2012, 12:57 – Test CTD, too shallow for reasonable LADCP measurements
Different Lag Results
no SADCP
Profile 95 on 10.06.2012, 08:21
Beam 3 warning
Large compass difference 20.4
Profile 96 on 10.06.2012, 09:05
Large compass difference 20.9
Profile 97 on 10.06.2012, 09:47
Beam 3 warning
Large compass difference 19.2
Profile 98 on 10.06.2012, 10:52
Beam 3 warning
Large compass difference 19.4
Profile 99 on 10.06.2012, 11:36
Beam 3 warning
Large compass difference 18.5
Profile 100 on 10.06.2012, 12:26
Beam 3 warning
Large compass difference 23.6
Profile 101 on 10.06.2012, 13:30 – no LADCP, microstructure probe test (abandoned)
Profile 102 on 10.06.2012, 14:24
Beam 3 warning
Large compass difference 27.7
Profile 103 on 10.06.2012, 15:36
Beam 3 warning
Large compass difference 23.8
Profile 104 on 10.06.2012, 16:46
Beam 3 warning
Large compass difference 25.6
Profile 105 on 10.06.2012, 18:40
Different Lag Results
Beam 3 warning
Large compass difference 20.0
Profile 106 on 10.06.2012, 19:45
Different Lag Results
Large compass difference 18.5
Profile 107 on 10.06.2012, 21:19

Large compass difference 16.6
Profile 108 on 10.06.2012, 22:20
Large compass difference 17.8
Profile 109 on 10.06.2012, 23:53
Beam 3 warning
Large compass difference 22.2
Profile 110 on 11.06.2012, 01:25
Beam 3 warning
Large compass difference 26.4
Profile 111 on 11.06.2012, 03:36
Beam 3 warning
Large compass difference 20.3
Profile 112 on 11.06.2012, 14:30 – no LADCP, microstructure probe test (abandoned)
Profile 113 on 11.06.2012, 21:46
Beam 3 warning
Profile 114 on 12.06.2012, 00:05
Large compass difference 17.5
Profile 115 on 12.06.2012, 11:34 – LADCP Profile ok
Profile 116 on 12.06.2012, 13:15
Large compass difference 17.6
Profile 117 on 12.06.2012, 23:50
Large compass difference 17.0
Profile 118 on 13.06.2012, 02:07
Large compass difference 17.7
Profile 119 on 13.06.2012, 04:36
Large compass difference 15.8
Profile 120 on 13.06.2012, 06:43
Large compass difference 17.1
Profile 121 on 13.06.2012, 08:19
Large compass difference 18.6
Upward looking LADCP swopped, now SN 14411 (IfM HH)
Profile 122 on 13.06.2012, 18:16 – LADCP Profile ok
Profile 123 on 13.06.2012, 19:53 – LADCP Profile ok
Profile 124 on 13.06.2012, 22:20 – LADCP Profile ok
Profile 125 on 14.06.2012, 00:42 – LADCP Profile ok
Profile 126 on 14.06.2012, 03:32 – LADCP Profile ok
Profile 127 on 14.06.2012, 05:56 – LADCP Profile ok
Profile 128 on 14.06.2012, 09:50 – LADCP Profile ok
Batterietausch
Profile 129 on 14.06.2012, 15:24 – LADCP Profile ok
Profile 130 on 14.06.2012, 17:42 – LADCP Profile ok
Profile 131 on 14.06.2012, 20:02 – LADCP Profile ok
Profile 132 on 14.06.2012, 22:49 – LADCP Profile ok
Profile 133 on 15.06.2012, 01:39 – LADCP Profile ok

Profile 134 on 15.06.2012, 08:09 – LADCP Profile ok
Profile 135 on 15.06.2012, 11:35 – LADCP Profile ok
Profile 136 on 15.06.2012, 12:59 – LADCP Profile ok
Profile 137 on 15.06.2012, 14:22 – LADCP Profile ok
Profile 138 on 15.06.2012, 15:52 – LADCP Profile ok
Profile 139 on 15.06.2012, 17:40 – LADCP Profile ok
Profile 140 on 15.06.2012, 19:05 – LADCP Profile ok
5 DN Files geschrieben, 2 UP Files geschrieben
Profile 141 on 15.06.2012, 22:13 – Communication via toughbook
Starten über langes Kabel nicht möglich, Ansprechen über Testkabel und Testschnittstelle im Hangar möglich (Toughbook).
LADCP wird nicht gestoppt, läuft die Profile 141 und 142 durch
Profile 142 on 15.06.2012, 23:39 – Communication via toughbook
LADCP um 00:55 gestoppt UK. Keine Datenaufzeichnung, Profile 141 und 142 existieren nicht.
Profile 143 on 16.06.2012, 03:50 – Communication via toughbook
LADCP automatisch gestartet 03:45 , gestoppt 05:01 DQ
Nur downlooking data
LADCP Profile ok
Profile 144 on 16.06.2012, 09:04 – Communication via toughbook
Gestartet/gestoppt UK
Nur downlooking data
LADCP Profile ok
Profile 145 on 16.06.2012, 11:24 – Communication via toughbook
Gestartet/gestoppt UK
Large compass difference 26.6
Profile 146 on 16.06.2012, 14:24 – Communication via toughbook
Gestartet/gestoppt UK
Increased error because of shear - inverse difference
No SADCP data
Nur downlooking data
Profile 147 on 16.06.2012, 17:47 – Communication via toughbook
Data missing, file size only 2KB. Unknown failure mode
Only downlooking file
Profile 148 on 16.06.2012, 19:37 – Communication via toughbook
Daten fehlen, Dateien nur 1KB groß. Fehler unbekannt.
Profile 149 on 16.06.2012, 23:14 – Communication via toughbook
No SADCP data
Profile 150 on 17.06.2012, 01:07 – Communication via toughbook
No SADCP data
Profile 151 on 17.06.2012, 04:33 – Communication via toughbook
No SADCP data
Profile 152 on 17.06.2012, 06:47 – Communication via toughbook
Processing fails shortly before end
Profile 153 on 17.06.2012, 08:22 – Communication via toughbook

Dateien fehlen !!! Nur DN, ausgelesen von AW
Profile 154 on 17.06.2012, 10:55 – Communication via toughbook
Yoyo-Station: 1600 m bis 10 m über Boden
No SADCP data
Profile 155 on 17.06.2012, 16:33 – Communication via toughbook
No SADCP data
Profile 156 on 17.06.2012, 19:16 – Communication via toughbook
No SADCP data
Profile 157 on 17.06.2012, 21:47 – Communication via toughbook
No SADCP data
Profile 158 on 18.06.2012, 00:26 – Communication via toughbook
No SADCP data
Profile 159 on 18.06.2012, 02:58 – Communication via toughbook
No SADCP data
Profile 160 on 18.06.2012, 05:30 – Communication via toughbook
No SADCP data
Profile 161 on 18.06.2012, 10:49 – Communication via toughbook
No SADCP data
Profile 162 on 18.06.2012, 11:48 – Communication via toughbook
No SADCP data
Profile 163 on 18.06.2012, 12:38 – Communication via toughbook
No SADCP data
Profile 164 on 18.06.2012, 13:33 – Communication via toughbook
No SADCP data
Profile 165 on 18.06.2012, 14:26 – Communication via toughbook
No SADCP data
Profile 166 on 18.06.2012, 15:18 – Communication via toughbook
No SADCP data
Profile 167 on 18.06.2012, 16:41 – Communication via toughbook
No SADCP data
Profile 168 on 18.06.2012, 17:57 – Communication via toughbook
No SADCP data
Profile 169 on 18.06.2012, 19:15 – Communication via toughbook
No SADCP data
Profile 170 on 18.06.2012, 20:53 – Communication via toughbook
No SADCP data
Profile 171 on 18.06.2012, 23:39 – Communication via toughbook
Battery empty, data incomplete, processing impossible, battery exchanged
Profile 172 on 19.06.2012, 02:13 – Communication via toughbook
Yoyo-Station: 1000 m to 10 m above bottom
No SADCP data
Profile 173 on 19.06.2012, 04:26 – Communication via toughbook
Yoyo-Station: 1000 m to 10 m above bottom
No SADCP data

Profile 174 on 19.06.2012, 07:24 – Communication via toughbook
No SADCP data
Profile 175 on 19.06.2012, 09:10 – Communication via toughbook
No SADCP data
Profile 176 on 19.06.2012, 10:43 – Communication via toughbook
No SADCP data
Profile 177 on 19.06.2012, 14:37 – Communication via toughbook – LADCP Profile ok
Yoyo-Station: 1000 m to 10 m above bottom
Profile 178 on 19.06.2012, 19:02 – Communication via toughbook – LADCP Profile ok
Profile 179 on 19.06.2012, 21:20 – Communication via toughbook
Found large timing difference between ADCPs
Profile 180 on 19.06.2012, 23:44 – Communication via toughbook – LADCP Profile ok
Profile 181 on 20.06.2012, 02:05 – Communication via toughbook – LADCP Profile ok
Profile 182 on 20.06.2012, 08:02 – Communication via toughbook – LADCP Profile ok
Profile 183 on 20.06.2012, 10:54 – Communication via toughbook – LADCP Profile ok
Profile 184 on 20.06.2012, 12:19 – Communication via toughbook – LADCP Profile ok
Profile 185 on 20.06.2012, 13:44 – Communication via toughbook – LADCP Profile ok

Appendix D Crew Members

R/V Maria S. Marian cruise 21/1b:

01	SCHMIDT, Ralf	Master
02	SOSSNA, Yves-Michael	Chief Officer
03	GÜNTHER, Jan Philipp	1st Officer
04	STEGMAIER, Eberhard	2nd Officer
05	SCHÜLER, Achim	Chief Engineer
06	BOY, Manfred	2nd Engineer
07	PLATHE, Hans - Dieter	3rd Engineer
08	SCHMIDT, Hendrik	Electrician
09	RIEDEL, Frank	Electronics
10	MAGGIULLI, Michael	System Operator
11	FRIESENBORG, Helmut	Fitter
12	BOSSELMANN, Norbert	Bosun
13	PESCHEL, Jens	SM
14	PLINK, Sebastian	SM
15	VREDENBORG, Enno	SM
16	EILTS, Enno	SM
17	DINSE, Dennis	SM
18	PETERS, Karsten	SM
19	SIEFKEN, Tobias	SM
20	SAUER, Jürgen	Motorman
21	ENNENGA, Johan	Cook
22	KROEGER, Sven	2nd Cook
23	JORDAN, Dieter	Steward
24	MÜLLER, Reinhard	Doctor

Appendix E List of Acronyms

AAW	Arctic Atlantic Water
ADCP	Acoustic Doppler Current Profiler
AUV	Autonomous Underwater Vehicle
CTD	Conductivity-Temperature-Depth
DSOW	Denmark Strait Overflow Water
DVL	Doppler Velocity Log
DVS	Central Data Distributer
INS	Inertial Navigation System
LADCP	Lowered Acoustic Doppler Current Profiler
LARS	Launch and Recovery System
LBL	Long Baseline Acoustic Navigation
MR	Microrider
MSS	Microstructure Sensor
PIES	Pressure Inverted Echosounder
RAW	Recirculating Atlantic Water
SST	Sea Surface Salinity
TSG	Thermosalinograph
VMADCP	Vessel-mounted Acoustic Doppler Current Profiler